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INDEX OF 3.2-MM AND 10.6-MICROMETERS IMAGE DATA TAPES.(U)
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1 OF 2
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TECHNICAL REPORT TR-77-2

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D.S.

INDEX OF 3.2-mm AND 10.6-μm IMAGE DATA TAPES

Physical Sciences Directorate
Technology Laboratory

1 February 1977

Approved for public release; distribution

US Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

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micrometers
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INDEX OF 3.2-mm AND 10.6-μm IMAGE DATA TAPES

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Physical Sciences Directorate
Technology Laboratory
US Army Missile Research and Development Command
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CONTENTS

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The original suggestion to simulate submillimeter images by operating at 940 GHz and scaling the range was made by Dr. J. Allen, Office of the Director of Defense Research and Engineering. The selection of target matrix was aided by Dr. V. Corcoran, IDA consultant to the Director of Defense Research and Engineering. Mr. Robert McMillan of Rome Air Development Center gave valuable assistance by smoothing the contractual support. Colonel T. M. Robinson, NGB, USPFO for California, arranged availability of target vehicles. Lieutenant Colonel Reigel, Commander 3d Battery, 185th Armored Battalion, California National Guard, provided support and allowed the use of facilities and equipment under his command. Dr. N. George, Dr. J. S. Bennett, and Dr. C. R. Christenson have been involved in fruitful discussions of imaging with coherent systems. The assistance provided by Dr. George in obtaining visual displays of some of the data is greatly appreciated. The author's collaborators in the US Army Missile Research and Development Command submillimeter program, Dr. R. L. Hartman and Dr. W. L. Gamble, were involved in this effort from its inception and have provided invaluable advice and support. Most of all, thanks goes to Dr. J. M. Baird and Mr. John F. Heney of Hughes Research Laboratory who were truly dedicated to the support of this mission.

I. INTRODUCTION

This report describes image data of military vehicles at wavelengths of 3.2 mm and 10.6 μm available on magnetic tape from the Physical Sciences Directorate, US Army Missile Research and Development Command (MIRADCOM), Redstone Arsenal, Alabama.

The images were obtained through the use of the Hughes Research Laboratories mobile image scanning equipment. All the data described here were taken 7 June 1976 through 11 June 1976 at a California National Guard Armory in San Diego, California. Thanks are due to Lt. Col Curtis E. Reigel, Commander, 3rd Battalion, 185th Armor, for providing support and allowing the use of the facilities and equipment under his command.

This report is to provide an index of the available images for prospective users. Additional study of the images and methods of processing them will be carried out both at Hughes Research Laboratories and MIRADCOM.

II. BACKGROUND

A basic research program was established in December 1975 at MIRADCOM to evaluate the submillimeter wavelength region of the electromagnetic spectrum for possible Army applications. The goal of this program is to determine if an all-weather capability will be provided by utilization of these wavelengths. Initial emphasis was created by an ASAP summer study in 1974 by Dr. Paul W. Kruse which suggested that submillimeter waves could provide sufficient resolution and inclement weather penetration to allow the Army to acquire, recognize, and direct conventional weapons fire onto hostile targets such as tanks and other military vehicles [1-4]. The 1976 ASAP summer study reviewed the MIRADCOM effort [5].

The primary reasons for selecting this wavelength region are as follows:

a) Millimeter and centimeter wavelengths are not seriously degraded by inclement weather but they cannot provide sufficient resolution for target identification without exceeding the restrictions placed on antenna size by operational systems.

b) Optical and infrared wavelengths can provide the required resolution for target identification but propagation of these wavelengths in inclement weather is poor.

c) Submillimeter wavelengths can be used with system compatible antenna sizes to provide a narrow beam that will minimize the problem of clutter returns and provide sufficient resolution for accurate target location, size discrimination, and shape recognition capability. Clear air attentuation is expected to be high but inclement weather effects should not seriously degrade the beam.

The characteristics of submillimeter waves suggest potential application in the following:

a) Terminal homing.

b) Target designation.

c) Active seekers.

d) Beam riders.

e) Prelaunch guidance.

f) Surveillance.

g) Target acquisition.

h) Secure communications.

i) Reducing system vulnerability to antiradiation missiles (ARM) and electronic countermeasures (ECM).

Before any application can be undertaken, a data base in the submillimeter region must be established. Propagation in conjunction with meteorological observations and data on target reflectivities and scene contrast needed for image capability predictions are the most important inputs needed for the data base.

A more specific list of the critical data inadequacies in the area of propagation can be given [6]. There are no experimental data on scattering. Measurements of absorption in clear air are limited and do not include detailed meteorological measurements. Observed fluctuations in attenuation are not explained. The theories on clear air absorption do not work well in the atmospheric windows. The data base for extinction in rain, snow, and fog is very limited. A bibliography to provide an introduction to the field of submillimeter propagation is available [7].

A program is currently under way at MIRADCOM to obtain a statistically meaningful data base for submillimeter propagation in the atmospheric windows at approximately 750, 850, and 1.3 mm [8].

It was decided that the most productive technique for evaluating the imaging capability at these wavelengths was not to build an imaging submillimeter radar but rather to use an existing 3.2-mm radar at ranges which simulate the resolution one would obtain with a submillimeter wave radar.

In addition to obtaining the simulated submillimeter data, high resolution images were obtained both at 3.2 mm and at 10.6 μm. These data are now available in digital format. The high resolution data allow digital image processing to be used to study the effects of image degradation and image enhancement.

The intensity of the returned signal is calibrated with respect to the return from a polished gold sphere. It is hoped that these calibrated data will be useful to system designers. Calibrated target signature data of this type are not available in the submillimeter wavelength region; neither are data available on optical properties of materials in this region. A program is begining at MIRADCOM to fill this gap. The 3.2-mm and 10.6-μm data will aid in interpretation and uation of the submillimeter target signature and otpical constant parameters.

III. DESCRIPTION OF THE IMAGE SCAN SYSTEM

There is a detailed description [9] of the image scanning equipment and the methods used to calibrate the equipment. A summary of that description will be given here.

A. The 3.2-mm Equipment

The 3.2-mm system used a Hughes LOW-1 backward wave oscillator (BWO) to provide at least 1 W of power to the 45-cm transmitting antenna. A separate receiving antenna with an identical aperture feeds the heterodyne receiver. At 14.6 m, the system resolution spot size (at the 3-dB points) is oval in shape with a height of 10 cm and a width of 8.2 cm. The calibration of the receiver is shown in Figure 1.

The system response was calibrated against the backscatter from a polished 50-mm (2-in.) diameter gold-plated chrome steel sphere. The sphere was assumed to have the theoretical radar cross section of $-26.9\ \mathrm{dB/m^2}$. The data are digitized into 12 bits and stored on magnetic tape for later processing. To convert this integer value to voltage, the relationship 10 V = 4096 is used. An effective radar cross section (RCS) referenced to the gold sphere can be calculated by using the following expression:

$$\mathrm{RCS}(\mathrm{dB/m^2}) = 6.91\left(\frac{I}{409.6} - V_s\right) - 26.9 \qquad (1)$$

where I = the integer value on the data tape and V_s = the voltage reading from the 50-mm gold sphere. The sphere voltage was taken at the end of every scan when the transmitter and receiver were parallel

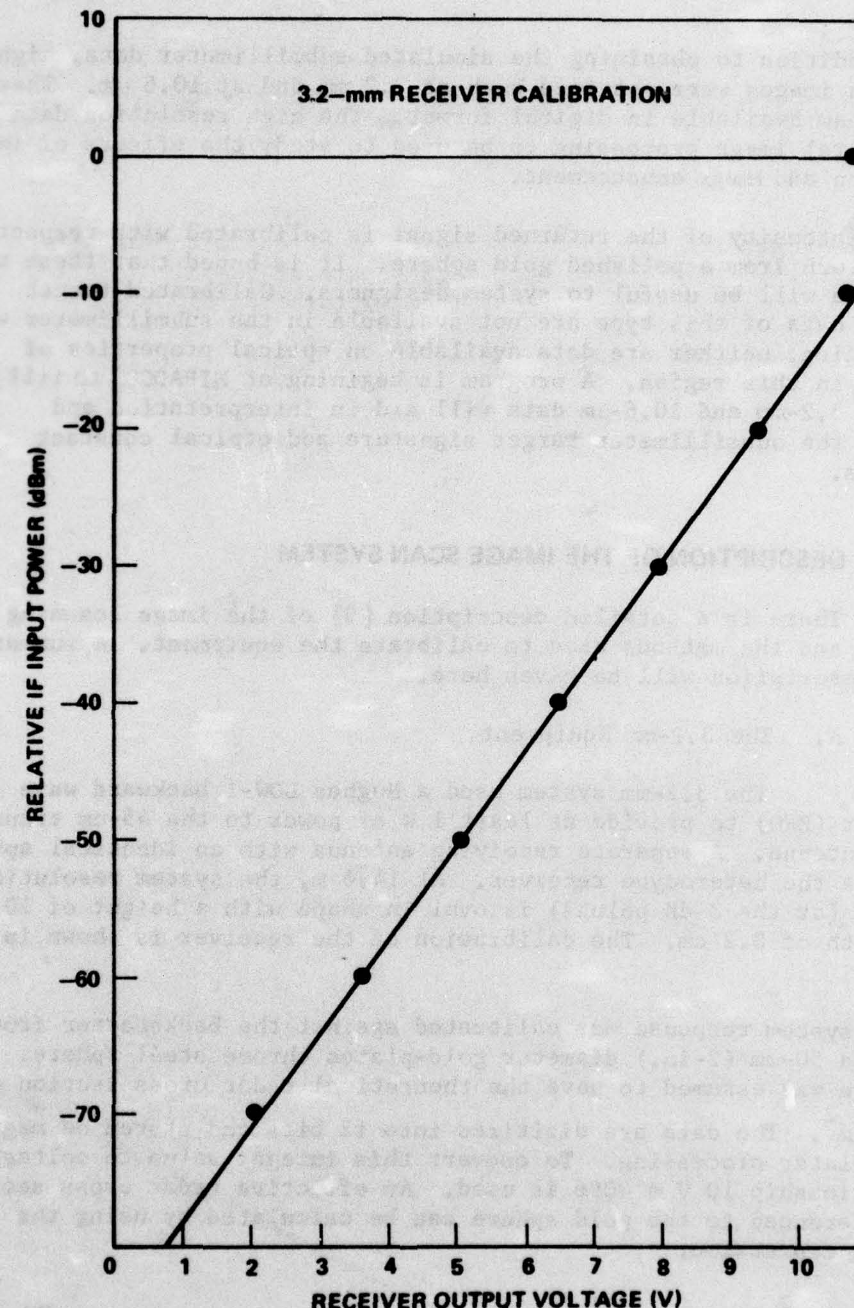


Figure 1. IF amplifier and detector calibration data.

polarized. When the transmitter and receiver were cross polarized, the following expression was used to calculate the backscattered intensity:

$$\text{Intensity (dB)} = 6.91 \left(\frac{I}{409.6} - 10\right) \quad . \qquad (2)$$

The accepted definition of radar cross section is the area intercepting that amount of power which, when scattered equally in all directions, produces an echo equal to that from the target [10]. Thus, a specular sphere with a geometrically projected area of a square meter (a radius of $1/\sqrt{\pi}$) has an RCS of a square meter. This definition implies that the target is smaller than the illuminating beam. Therefore, the RCS calculated using Equation (1) should be used as a calibrated reflectance, not as an RCS usable in the radar range equations.

B. The 10.6-μm System

A 1-W CO_2 laser lasing on the P20 line provides the transmitting signal for the 10.6-μm imaging system. The natural divergence of the laser output beam results is a 4-cm, horizontally polarized, illuminated spot on a target at 14.6 m. A 2-mm diameter liquid nitrogen cooled HgCdTe detector positioned in the back focal plane of a 20-cm diameter F/4 telescope acts as the receiver. The receiver was polarization insensitive. Synchronous video detection at 1 K Hz with an integration time of 0.01 sec is used to eliminate the effects of background radiation.

The 10.6-μm images differ from those obtained at 3.2 mm in several important respects:

1) The resolution of the 10.6-μm transmitter is approximately twice that of the 3.2-mm transmitter (4 cm versus 10 cm).

2) The receiver in the 10.6-μm system performs speckle averaging resulting in the 3.2-mm data having a larger component of speckle noise. This speckle noise further reduces the effective resolution of the 3.2-mm system [11, 12].

3) Heterodyne detection was used at 3.2 mm but video detection was used at 10.6 μm.

4) The 3.2-mm receiver is sensitive to only one polarization while the 10.6-μm receiver is polarization insensitive.

The calibration curve for the 10.6-μm system is shown in Figure 2. The data are stored digitally in the same format at the 3.2-mm image data. When the reflected signal is referenced to the same gold sphere as was used in the 3.2-mm calibration, the following equation gives the effective cross section:

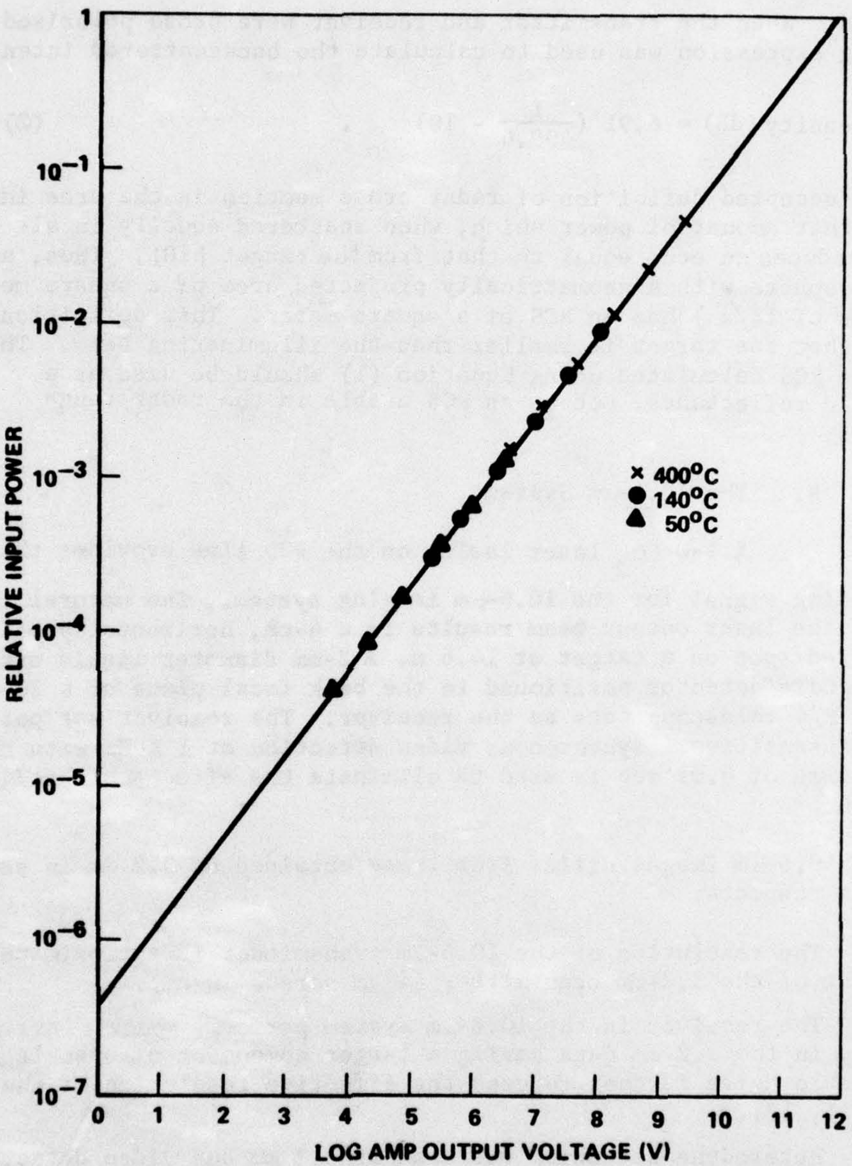


Figure 2. Plot of calibrated data for 10.6-μm receiver.

$$\text{RCS (dB/m}^2) = 5.346\left(\frac{I}{409.6} - V_s\right) - 26.93 \qquad (3)$$

The return from the gold sphere, V_s, was recorded at the end of each run. The same warning should be kept in mind when using Equation (3) that was given with Equation (1).

When the exterior light level remained constant, very good visible records were obtained (Figure 3a).

C. Visible System

A passive visible system with resolution of ~3 mrad was used to provide a boresight reference record for the 3.2-mm data. However, the lack of an automatic gain control (AGC) on this data channel and the fact that the light levels often changed rapidly during a scan produced streaking in most of the visible sensor images (Figure 3b). Nevertheless, the visible images can still be used to obtain the spatial origin of the reflectivity data in the 3.2-mm and 10.6-μm records.

D. Accessory Equipment

An equipment van and azimuth and elevation (AZ/EL) scanning pedestal from a 584 radar system were used to house all of the equipment and provide the scanning capability needed to form images. Figure 4 shows the system in operation at San Diego, California.

The scanning motors in the AZ/EL pedestal were replaced by stepping motors. Data were recorded when the motors were stepped from top to bottom, left to right. In all but two cases, the scattered intensity was recorded every 3.5 mrad in AZ and 3.4 mrad in EL.

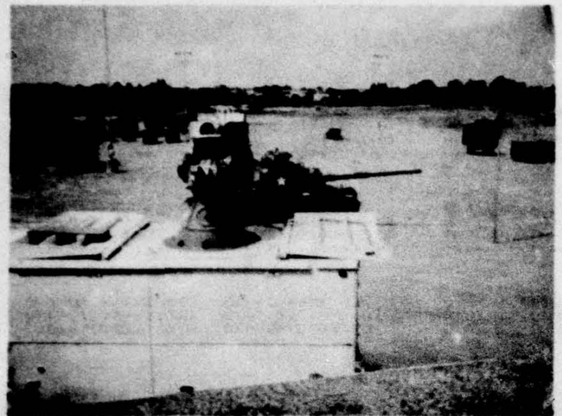
The raw data tapes were returned to Hughes Research Laboratories where they were read, unpacked into separate computer files for each wavelength, and stored on a final 9-track data tape at a density of 800 BPI. The 12-bit work for each intensity is right-justified into a 16-bit work and written into two bytes on the tape. Each file on the data tape contains one image written in a TV raster format a row at a time. The data files are blocked into records 2048 bytes long (1024 intensity readings) without regard to the raster format. If the last record of a file does not contain 2048 bytes, then the remaining bytes are filled with zeros. Figure 5 shows the first 3 image rows of file No. 32.

The first file contains an EBCDIC listing of the data tape directory. A printout of this file is shown in Figure 6. The remaining 135 files contain the binary image data. In each data file, the first three intensities have been replaced by the number of columns, the number of rows, and a zero (first three numbers in the listing shown in Figure 5).

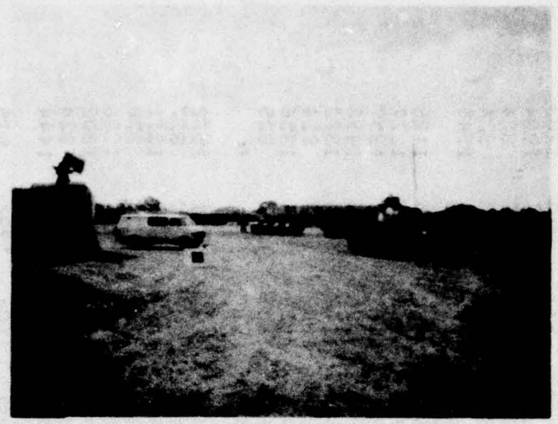
(a) FILE NO. 31

(b) FILE NO. 10

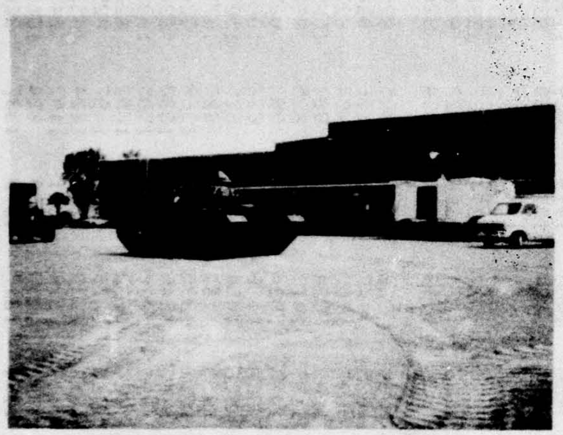
Figure 3. Visible image files.



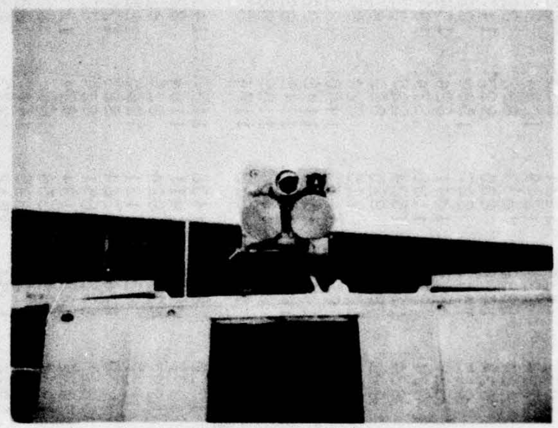
VIEW FROM SCANNER TO TARGET



SIDE VIEW. NOTE CALIBRATION
SPHERE MOUNTED ON POLE BY TANK



VIEW FROM TARGET TO SCANNER



SCANNER CLOSE–UP

Figure 4. Experimental equipment and operational arrangement.

FILE NUMBER 32

IMAGE ROW NUMBER 1

174	73	0	1470	826	1394	825	1121	1541	1136
824	1544	824	1502	826	824	825	825	1575	1215
825	823	1132	825	1283	1103	825	824	1034	1357
1310	1047	824	1321	825	827	823	824	825	1203
824	824	824	1249	1294	827	1562	1208	746	1094
1311	824	1338	1033	822	823	826	1521	823	824
1684	824	1490	825	827	1473	823	824	1210	824
822	825	1342	827	1588	825	1606	1529	824	1545
1543	826	824	1041	824	1563	1627			
1435	824	824	1108	824	1397	1642	824	1285	1128
1429	824	1119	1524	825	829	1415	1060	885	1277
1353	823	826	825	822	825	827	1303	1249	1257
1400	824	1235	825	824	861	943	825	1375	1498
825	1592	825	1173	1400	824	824	1200	824	1372
823	1361	1460	1160	1142	824	1253	1349	1250	824
824	824	1008	1081	1343	824	1425	823	824	1356
1239	1199	825	1414	1109	823	1483	1633	1331	825
1077	824	992	822	1174	824	824			

IMAGE ROW NUMBER 2

824	1700	825	1436	1107	1412	1400	823	1081	1572
824	1377	825	1411	1164	824	1170	1419	1376	827
879	1277	1255	824	825	825	1469	1455	1603	1211
1088	827	825	1121	1265	1253	1396	824	1454	870
822	878	1144	1764	823	1294	1104	824	826	1108
825	827	1329	1051	824	824	1400	1324	825	1008
824	825	824	1134	824	1231	1016	824	824	824
824	1384	995	1350	1606	823	825	1013	825	1444
975	1609	726	825	1647	824	1293			
1235	1394	1354	1512	1372	823	821	1104	1394	825
1213	1385	859	823	1006	1500	824	1466	1331	825
824	826	1005	1419	824	1136	825	1448	1115	824
1352	824	824	1019	1360	825	1152	822	1173	1174
824	1018	824	1391	824	824	825	823	1045	1667
1333	1190	824	1468	1215	1257	1053	977	972	825
1363	824	827	824	927	1288	1031	824	1174	824
1316	1186	824	1366	823	826	824	826	1568	1190
824	824	1198	1021	824	826	824			

IMAGE ROW NUMBER 3

1291	960	826	1560	825	825	1466	825	1052	824
1328	825	1477	1323	1116	824	1361	826	1099	825
825	823	1707	1332	1484	827	824	1147	1175	864
823	1508	824	825	824	1552	824	824	822	1317
1387	1185	1477	1397	825	824	825	825	824	822
824	1073	824	824	993	825	823	826	1372	1404
824	824	1139	826	826	1088	824	1371	1343	1560
823	826	1454	927	825	1509	1060	825	827	1491
824	828	1167	1468	827	1677	826			
824	1513	825	1241	1368	824	1383	823	824	1417
824	1442	1345	824	1330	824	825	824	1328	824
825	1495	1238	824	1585	1631	827	825	825	1488
1395	826	1230	1160	1652	824	1259	823	825	824
823	825	1278	825	1497	825	824	823	1041	823
1406	1398	1373	826	1624	1452	879	826	1244	824
1268	1429	824	1321	1193	1243	824	824	1517	823
824	1302	825	1259	824	1613	821	824	824	1156
1518	1041	1217	1440	1387	824	824			

Figure 5. Sample of image data in digital format.

```
HUGHES/MICOM MULTISPECTRAL SCAN DATA

     THIS TAPE CONTAINS SCAN DATA TAKEN BY HUGHES
RESEARCH LABORATORY SPONSORED BY ARMY MISSILE COMMAND.
THE DATA WAS TAKEN DURING THE WEEK OF JUNE 7, 1976
IN SAN DIEGO. THE TARGETS ARE AN M48A5 TANK AND ASSORTED
MILITARY TRUCKS AND JEEPS. THE WAVELENGTHS ARE 3.2 MM,
10.6 MICRON (BOTH ACTIVE SYSTEMS), AND PASSIVE
VISIBLE. (IN SOME CASES THE VISIBLE IMAGES ARE EMPTY
DUE TO DARKNESS DURING SCANNING.)

     FOR FURTHER INFORMATION CONTACT ..
          B. D. GUENTHER (MICOM)  (205) 876-3820
          J. M. BAIRD     (HUGHES) (213) 456-6411

TAPE CHARACTERISTICS
.... ...............

.. NO LABEL
.. 800 BPI (LOW DENSITY)
.. BLOCKING SIZE 2048
.. ALL FILES ARE BINARY EXCEPT FOR
     THE FIRST FILE WHICH IS EBCDIC.
.. INTENSITIES ARE 12 BITS AND ARE RIGHT JUSTIFIED IN 16 BITS
     (TWO INTENSITIES PER 32 BIT WORD)**
.. 9 TRACK TAPE
.. 136 FILES

**
   NOTE .. THE UPPER LEFT THREE INTENSITIES
           CONTAIN THE FOLLOWING
           (1,1) - NUMBER OF COLUMNS
           (2,1) - NUMBER OF ROWS
           (3,1) - ZERO FILLED


TAPE DIRECTORY
..............

     THE FOLLOWING IS A DIRECTORY OF THE MICOM DATA TAPE WHERE
.. THE FILES ARE LISTED IN THE ORDER OF OCCURENCE ON THE TAPE
.. EACH TAPE NUMBER REFERS TO THE ORIGINAL DATA TAPE RECORD
.. EACH SCAN NUMBER REPRESENTS ONE SCAN WITH THREE SENSORS
.. THE WAVELENGTH USED IS DESCRIBED
.. THE BITS PER INTENSITY IS 12 (RIGHT JUSTIFIED IN 16 BITS)
.. THE NUMBER OF ROWS (VERTICAL DIMENSION) PER PICTURE IS GIVEN
.. THE NUMBER OF COLUMNS (HORIZONTAL DIMENSION) PER PICTURE IS GIVEN

CAUTION: THE FIRST FILE IS EBCDIC THE 135 FOLLOWING ARE BINARY.
```

(a)

Figure 6. EBCDIC listing of the data tape directory.

FILE NO.	TAPE NO.	SCAN NO.	WAVELENGTH	BITS	SIZE COL	ROW
....	....	....	....	....	...	...
1	N/A	N/A	(TEXT HEADER	...	EBCDIC)	
2	27	01	3.2 MM	(16	18	20)
3			10.6 MICRON	(16	18	20)
4			VISIBLE	(16	18	20)
5	27	02	3.2 MM	(16	18	19)
6			10.6 MICRON	(16	18	19)
7			VISIBLE	(16	18	19)
8	27	03	3.2 MM	(16	174	96)
9			10.6 MICRON	(16	174	96)
10			VISIBLE	(16	174	96)
11	27	04	3.2 MM	(16	147	98)
12			10.6 MICRON	(16	147	98)
13			VISIBLE	(16	147	98)
14	27	05	3.2 MM	(16	102	96)
15			10.6 MICRON	(16	102	96)
16			VISIBLE	(16	102	96)
17	27	06	3.2 MM	(16	6	98)
18			10.6 MICRON	(16	6	98)
19			VISIBLE	(16	6	98)
20	27	07	3.2 MM	(16	99	98)
21			10.6 MICRON	(16	99	98)
22			VISIBLE	(16	99	98)
23	27	08	3.2 MM	(16	90	98)
24			10.6 MICRON	(16	90	98)
25			VISIBLE	(16	90	98)
26	27	09	3.2 MM	(16	117	72)
27			10.6 MICRON	(16	117	72)
28			VISIBLE	(16	117	72)
29	27	10	3.2 MM	(16	102	73)
30			10.6 MICRON	(16	102	73)
31			VISIBLE	(16	102	73)
32	27	11	3.2 MM	(16	174	73)
33			10.6 MICRON	(16	174	73)
34			VISIBLE	(16	174	73)
35	27	12	3.2 MM	(16	213	64)
36			10.6 MICRON	(16	213	64)
37			VISIBLE	(16	213	64)
38	28	01	3.2 MM	(16	87	52)
39			10.6 MICRON	(16	87	52)
40			VISIBLE	(16	87	52)
41	28	02	3.2 MM	(16	24	67)
42			10.6 MICRON	(16	24	67)
43			VISIBLE	(16	24	67)
44	28	03	3.2 MM	(16	201	65)
45			10.6 MICRON	(16	201	65)
46			VISIBLE	(16	201	65)
47	28	04	3.2 MM	(16	144	76)
48			10.6 MICRON	(16	144	76)
49			VISIBLE	(16	144	76)
50	28	05	3.2 MM	(16	156	98)
51			10.6 MICRON	(16	156	98)
52			VISIBLE	(16	156	98)
53	28	07	3.2 MM	(16	108	64)
54			10.6 MICRON	(16	108	64)
55			VISIBLE	(16	108	64)
56	28	08	3.2 MM	(16	216	90)
57			10.6 MICRON	(16	216	90)
58			VISIBLE	(16	216	90)
59	28	09	3.2 MM	(16	168	43)
60			10.6 MICRON	(16	168	43)
61			VISIBLE	(16	168	43)
62	28	10	3.2 MM	(16	186	41)
63			10.6 MICRON	(16	186	41)
64			VISIBLE	(16	186	41)
65	28	11	3.2 MM	(16	99	44)

(b)

Figure 6. (Continued).

66			10.6 MICRON	(16	99	44)
67			VISIBLE	(16	99	44)
68	28	12	3.2 MM	(16	156	88)
69			10.6 MICRON	(16	156	88)
70			VISIBLE	(16	156	88)
71	28	13	3.2 MM	(16	111	44)
72			10.6 MICRON	(16	111	44)
73			VISIBLE	(16	111	44)
74	28	14	3.2 MM	(16	225	100)
75			10.6 MICRON	(16	225	100)
76			VISIBLE	(16	225	100)
77	29	01	3.2 MM	(16	123	69)
78			10.6 MICRON	(16	123	69)
79			VISIBLE	(16	123	69)
80	29	02	3.2 MM	(16	99	103)
81			10.6 MICRON	(16	99	103)
82			VISIBLE	(16	99	103)
83	29	03	3.2 MM	(16	108	79)
84			10.6 MICRON	(16	108	79)
85			VISIBLE	(16	108	79)
86	29	04	3.2 MM	(16	120	78)
87			10.6 MICRON	(16	120	78)
88			VISIBLE	(16	120	78)
89	29	05	3.2 MM	(16	201	97)
90			10.6 MICRON	(16	201	97)
91			VISIBLE	(16	201	97)
92	29	06	3.2 MM	(16	183	76)
93			10.6 MICRON	(16	183	76)
94			VISIBLE	(16	183	76)
95	29	07	3.2 MM	(16	183	89)
96			10.6 MICRON	(16	183	89)
97			VISIBLE	(16	183	89)
98	29	08	3.2 MM	(16	174	100)
99			10.6 MICRON	(16	174	100)
100			VISIBLE	(16	174	100)
101	29	09	3.2 MM	(16	75	100)
102			10.6 MICRON	(16	75	100)
103			VISIBLE	(16	75	100)
104	29	11	3.2 MM	(16	102	95)
105			10.6 MICRON	(16	102	95)
106			VISIBLE	(16	102	95)
107	29	12	3.2 MM	(16	78	95)
108			10.6 MICRON	(16	78	95)
109			VISIBLE	(16	78	95)
110	29	13	3.2 MM	(16	158	59)
111			10.6 MICRON	(16	158	59)
112			VISIBLE	(16	158	59)
113	29	14	3.2 MM	(16	129	62)
114			10.6 MICRON	(16	129	62)
115			VISIBLE	(16	129	62)
116	29	15	3.2 MM	(16	63	36)
117			10.6 MICRON	(16	63	36)
118			VISIBLE	(16	63	36)
119	29	16	3.2 MM	(16	81	36)
120			10.6 MICRON	(16	81	36)
121			VISIBLE	(16	81	36)
122	29	17	3.2 MM	(16	132	42)
123			10.6 MICRON	(16	132	42)
124			VISIBLE	(16	132	42)
125	29	18	3.2 MM	(16	81	49)
126			10.6 MICRON	(16	81	49)
127			VISIBLE	(16	81	49)
128	29	19	3.2 MM	(16	84	48)
129			10.6 MICRON	(16	84	48)
130			VISIBLE	(16	84	48)
131	29	20	3.2 MM	(16	75	48)
132			10.6 MICRON	(16	75	48)
133			VISIBLE	(16	75	48)
134	29	21	3.2 MM	(16	75	48)
135			10.6 MICRON	(16	75	48)
136			VISIBLE	(16	75	48)

SCAN 06 OF TAPE 28 AND SCAN 10 OF TAPE 29
DID NOT CONTAIN ANY DATA.

(c)

Figure 6. (Concluded).

IV. DATA PROCESSING

The digital records have 4096 gray levels available; no image display can provide such a large dynamic range. It is therefore necessary to process the digital data before creating a visual record. One of the most straightforward methods of converting the digital data to useable gray scale values is to perform a linear mapping of the form:

$$I(\text{display}) = 256\left(\frac{I_o - I_{min}}{I_{max} - I_{min}}\right) . \qquad (4)$$

This simple mapping function is shown graphically in Figure 7. It converts the 12-bit digital data to 8-bit gray scale data and was used to create all of the images shown in this report.

Mapping of one image intensity into a new image intensity, independent of position, is called point processing. Point processing is one of a number of digital image processing techniques which can be used to provide the viewer with information or insight about the image [13]. The sole purpose of the point processing function shown in Figure 7 was to provide a visual record of the data file. Follow-on work will examine the usefulness of more complicated digital image enhancement techniques.

V. DATA DISPLAY

During a scan, a composite image was produced in the radar van by exposing a polaroid film to an oscilloscope trace whose x and y deflections are associated with the AZ/EL scan and whose z-axis modulation is associated with signals from the three sensors. An example of such a composite image is shown in Figure 8. The images from the top to bottom are associated with the 10.6-μm, visible, and 3.2-mm sensors, respectively. These composite displays provide the operator with evidence that a successful scan has been completed but very little information about the quality of the images is provided by this crude display.

Once the data have been obtained and a final data tape created, digital image processing can be used to provide images for any display. Figure 9a shows the easiest display to implement. The digital image data were mapped onto the integers from 0 to 2 and a line printer was used to generate the image. Another simple method for generating visual images utilizing equipment available in most laboratories is shown in Figure 9b. A Versatec Matrix Model 1200A is used to print, in binary format, an image with eight grey levels.

There are several types of display devices available which can provide high quality images from digital data. Figure 10 shows images produced by two such devices. On the left of Figure 10 is a composite

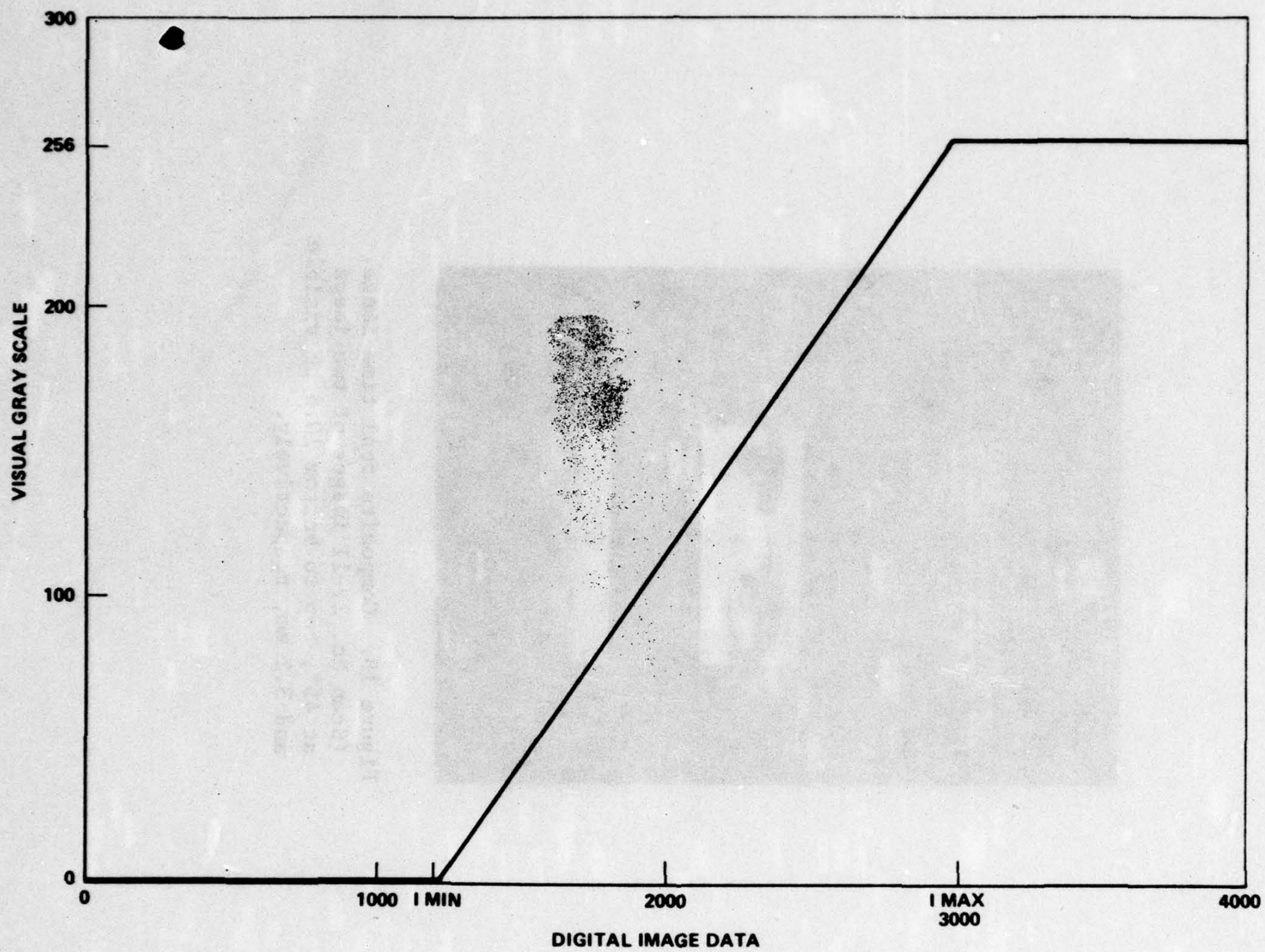


Figure 7. Linear mapping used for point processing.

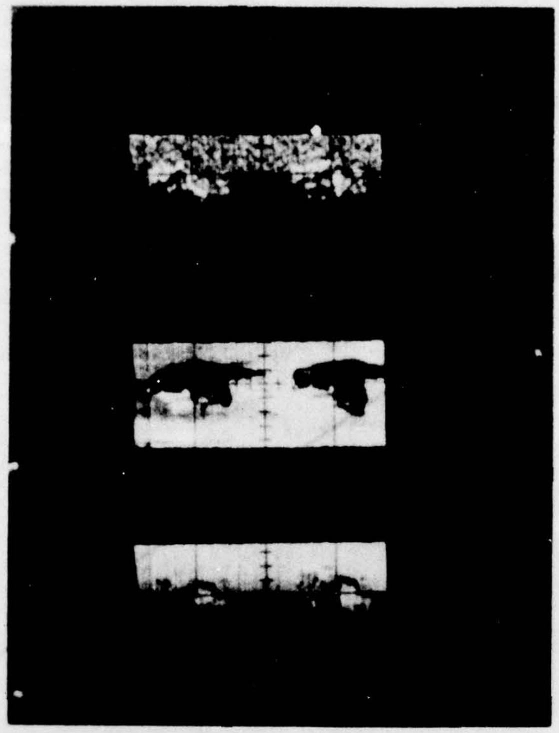
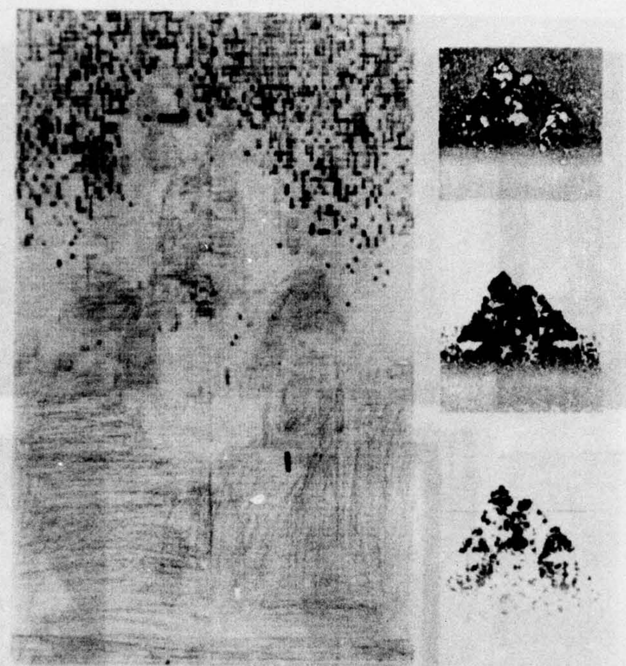


Figure 18. Composite real time image. (Scan No. 27-11 images of two jeeps at 45°, top to bottom 10.6 μm visible and 3.2 mm, respectively.



a b

Figure 9. Image file No. 14 produces on line printer (a). The numbers 0 and 2 have been shaded with a colored pencil to enhance the contrast. Three printouts (b) of image file No. 14 using a versatec plotter and three different point processing functions.

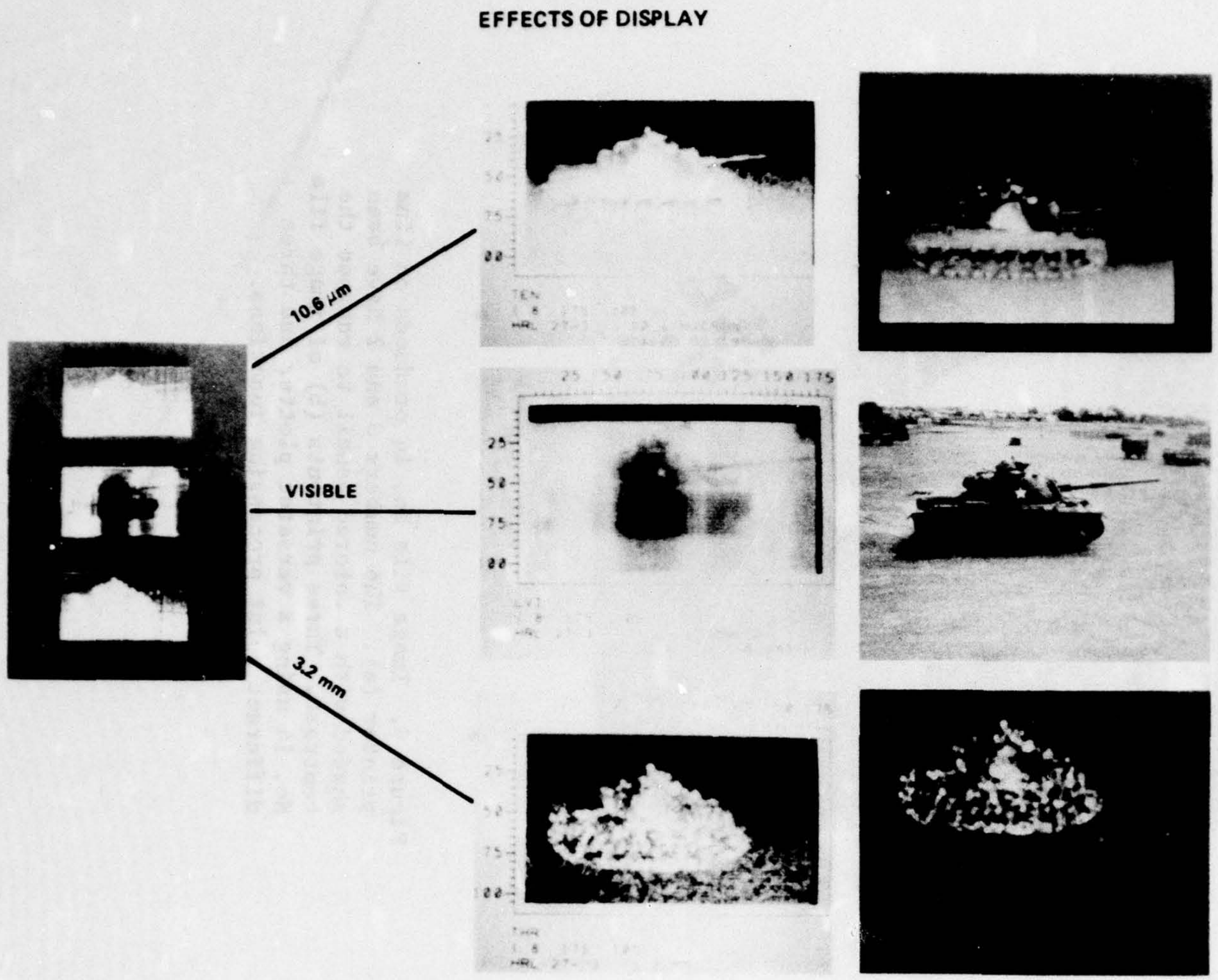


Figure 10. Comparison of image display devices.

image produced during a scan in real time. The center column of images contains photographs of a Conographics Model C9 gray level cathode ray tube (CRT) computer terminal which is capable of displaying up to 256 gray levels in a 1024 by 1024 pixel image. The photographs are a poor representation of the actual images because the film does not have the dynamic range of the display; nor is the film response matched to the display.

The highest quality hard compy images were produced by a flying spot scanner with matched photographic equipment. These images are shown in the right-hand column of Figure 11. The visible image is a normal photograph included for reference.

VI. TARGETS

The targets used to generate the images on the data tape are shown in Figure 10. The mess truck and trailer are a mobile kitchen and supply trailer constructed from plywood on a standard Army truck bed. The paint samples used in this experiment were made according to MIL specification of 1.5-ft aluminum squares. The top coats used were:

a) TT-E-489 gloss enamel, black No. 17038.

b) MIL-E-52227 semigloss enamel, olive drab No. 24037.

c) TT-E-527 lusterless enamel, olive drab No. 34087.

d) TT-E-516 lusterless enamel, white No. 37875.

e) TT-E-489 gloss enamel, black No. 17038.

f) MIL-E-46136 semigloss solar heat reflecting enamel, Type II, olive drab No. 24087 over an undercoat of MIL-E-46127 gray solar heat reflecting paint.

g) MIL-E-46096 lusterless solar heat reflecting enamel, olive drab No. 34087 over an undercoat of TT-E-516.

Different primers were used on the two sides of the aluminum plates, as follows:

a) TT-P-1757 zinc chromate primer, green No. 34141.

b) MIL-P-52192 epoxy primer, red. Only samples with the first undercoat were measured due to high winds. In addition to the painted samples, scans over the following unpainted samples were made:

1) Plywood behind canvas.

2) Aluminum behind canvas.

3) Galvanized steel samples produced by two different types of surface treatment were used.

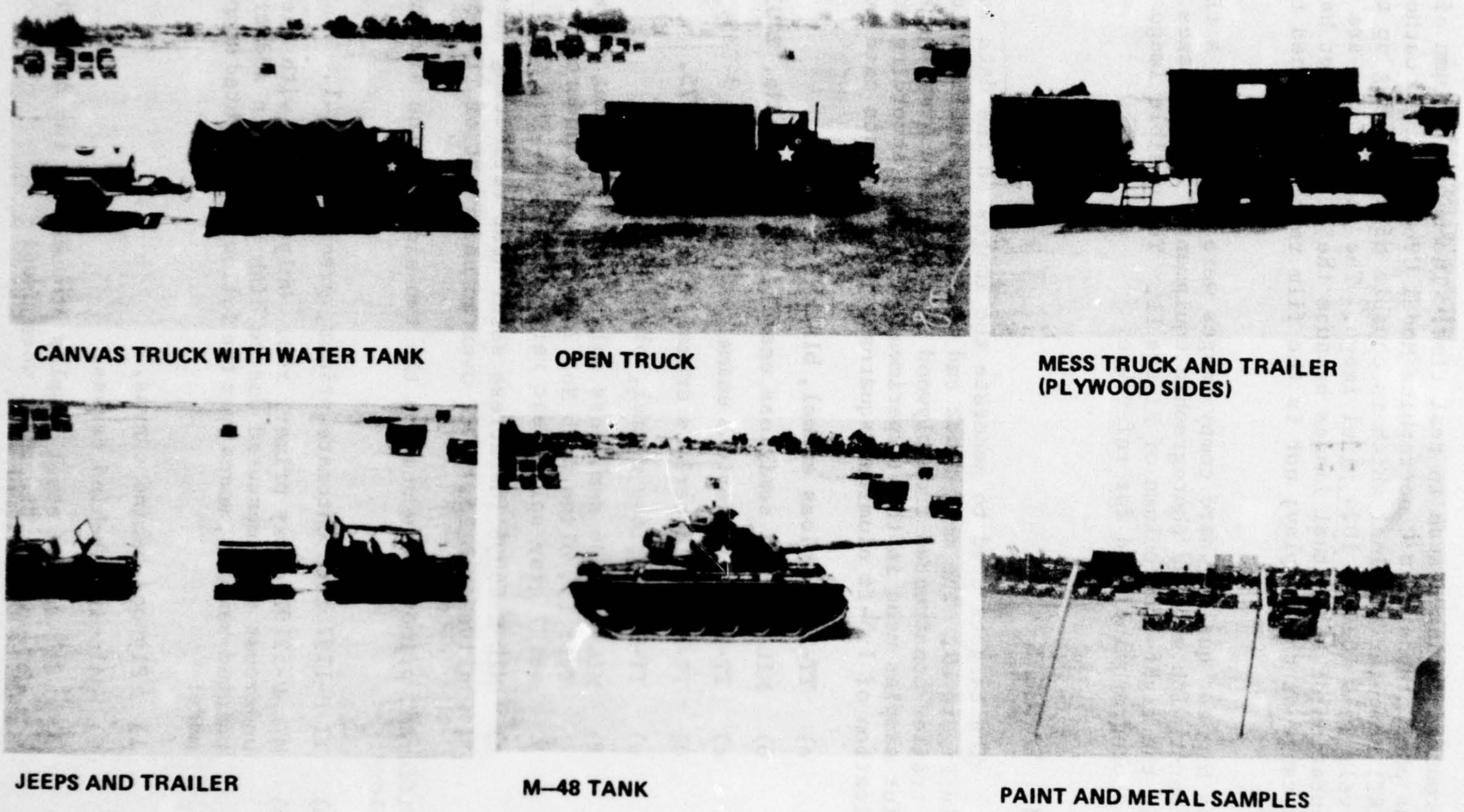


Figure 11. Targets.

4) 304 stainless steel.

5) 410 stainless steel.

6) Unpainted aluminum.

Appendix A provides detailed information about the contents of the 3.2-mm and 10.6-μm files recorded on the data tape. A photograph of the target is included with the other information. The histograms of reflectivity values provided with each file present graphically the information content of the image contained in a given dynamic range. They also provide the information needed to perform certain types of processing.

The histograms, when used in conjunction with a program such as BIWT (Appendix B), provide information about the spatial origin of given reflectivity values. Figure 12 demonstrates the implementation of this "intensity disection" of an image. Figure 12a is from file No. 11 and is a 3.2-mm image of a tank taken with the transmit and receive antennas parallel polarized. Figure 12b is from file No. 98 and is identical to Figure 12a except that the transmit and receive antennas are cross polarized. Figure 12c is the 10.6-μm image of the same target and is from file No. 12.

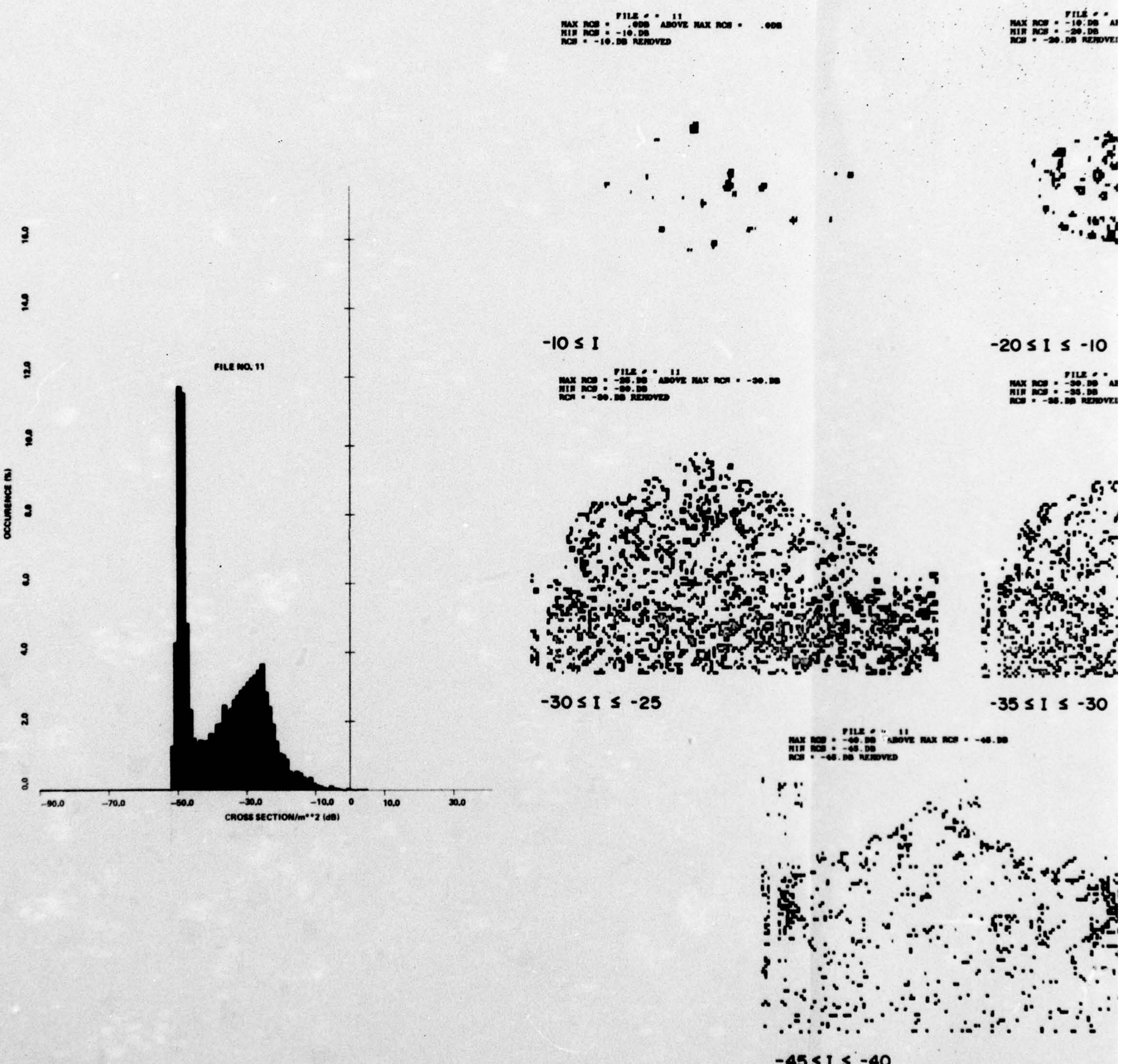
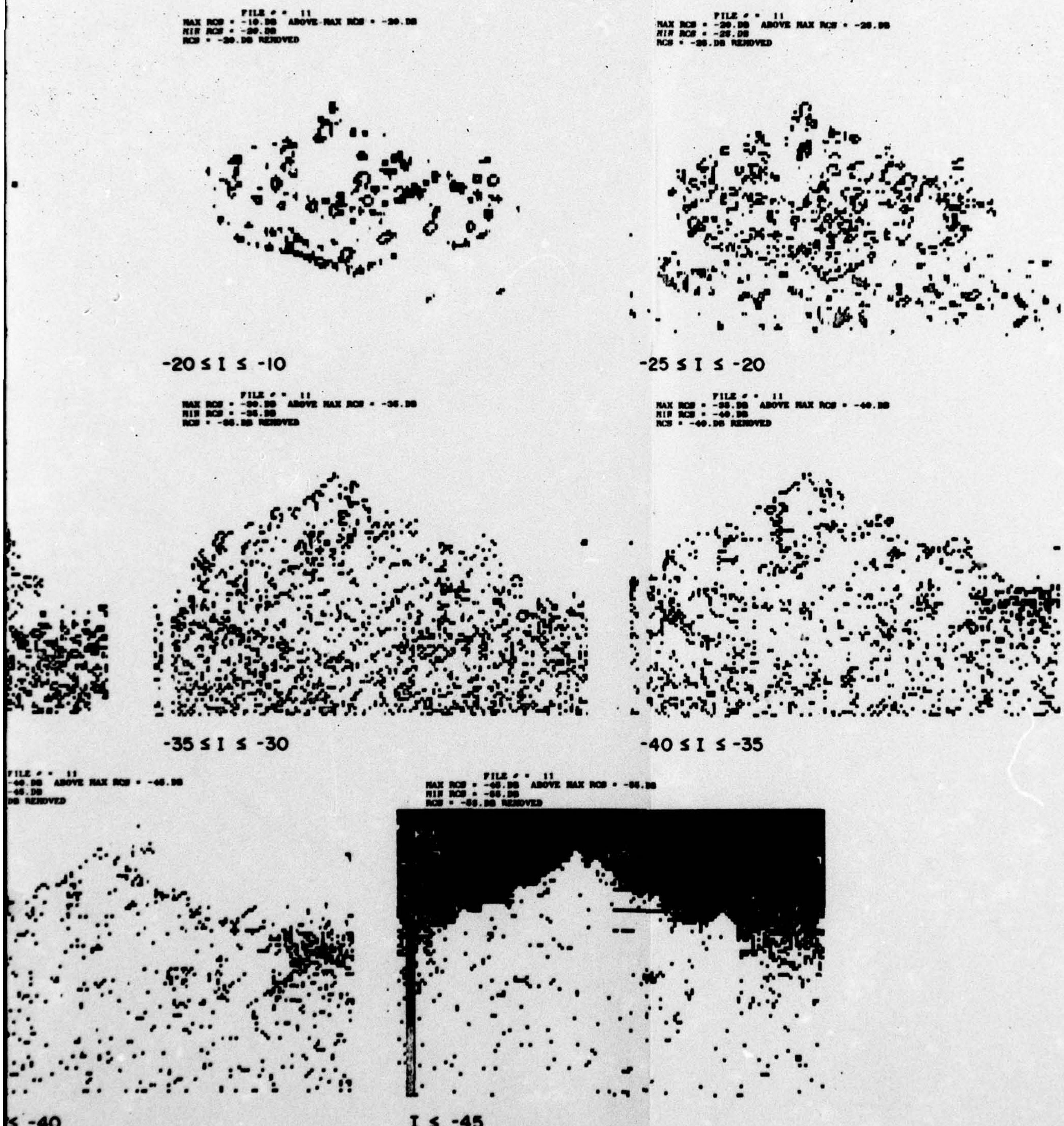
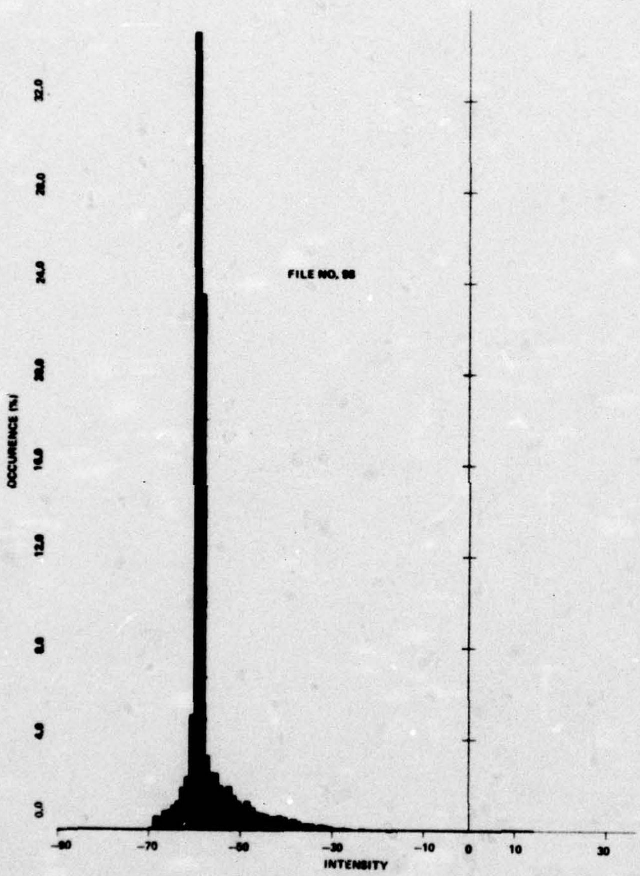


Figure 12a. Intensity dissection of



Intensity dissection of image.



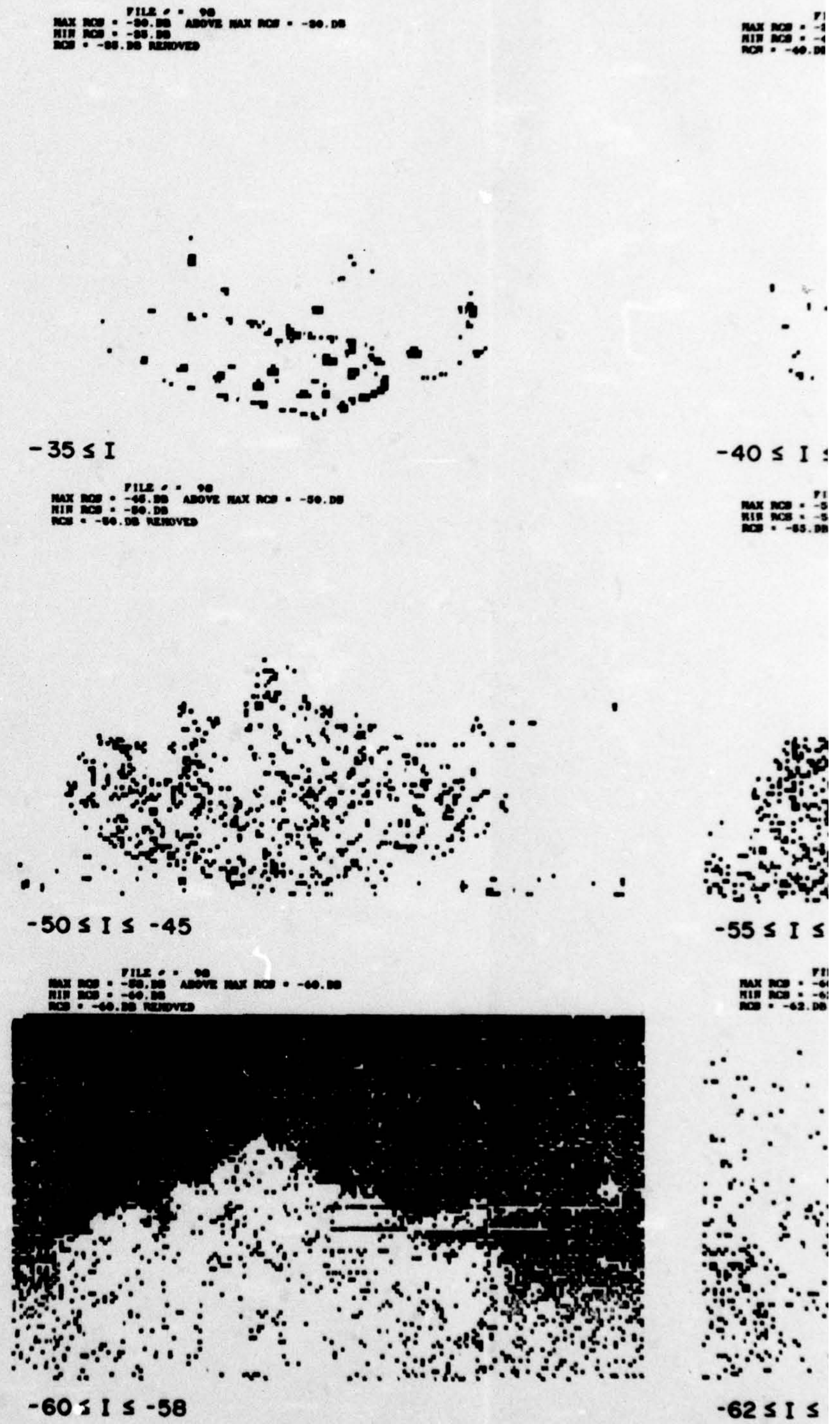
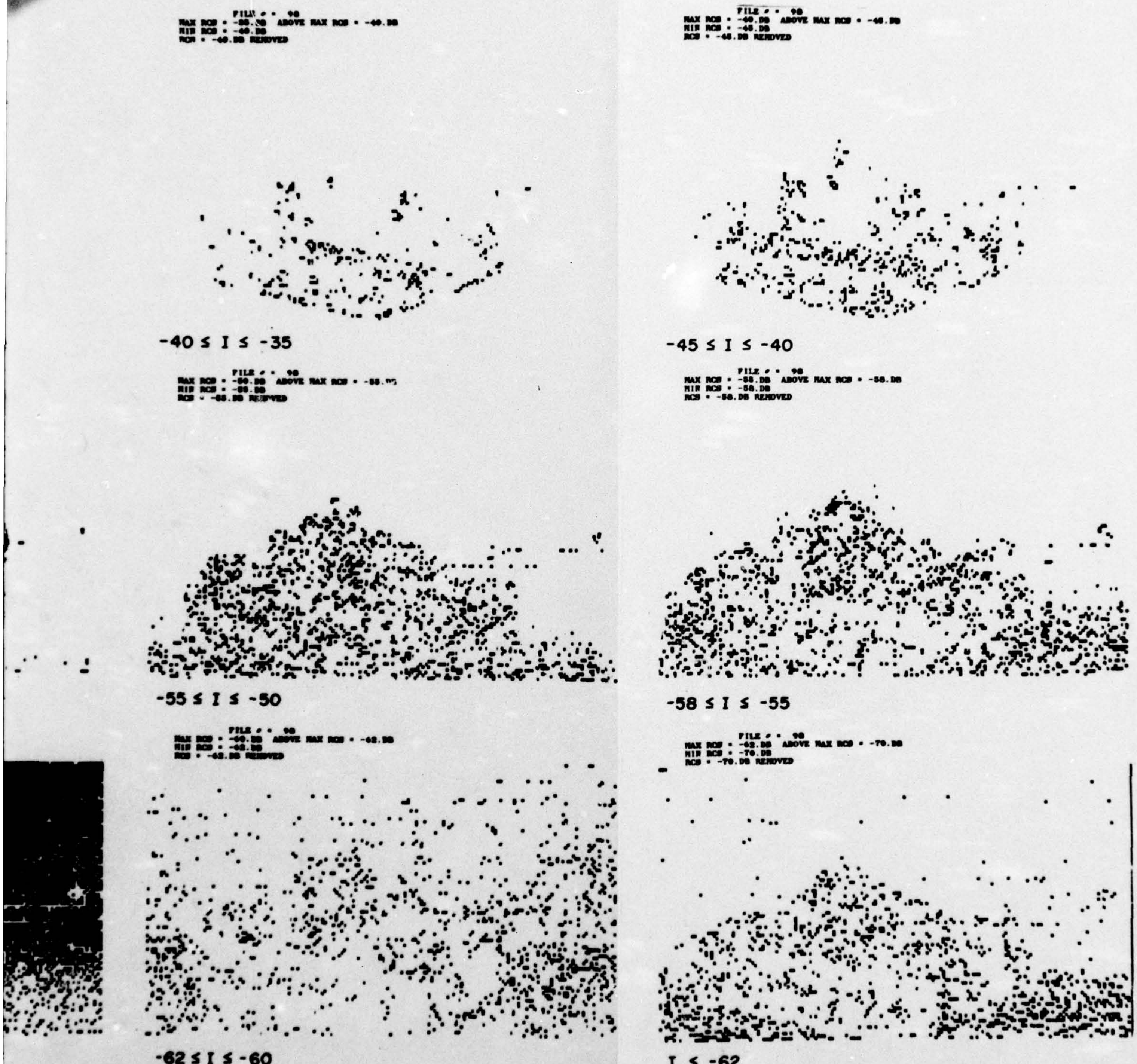
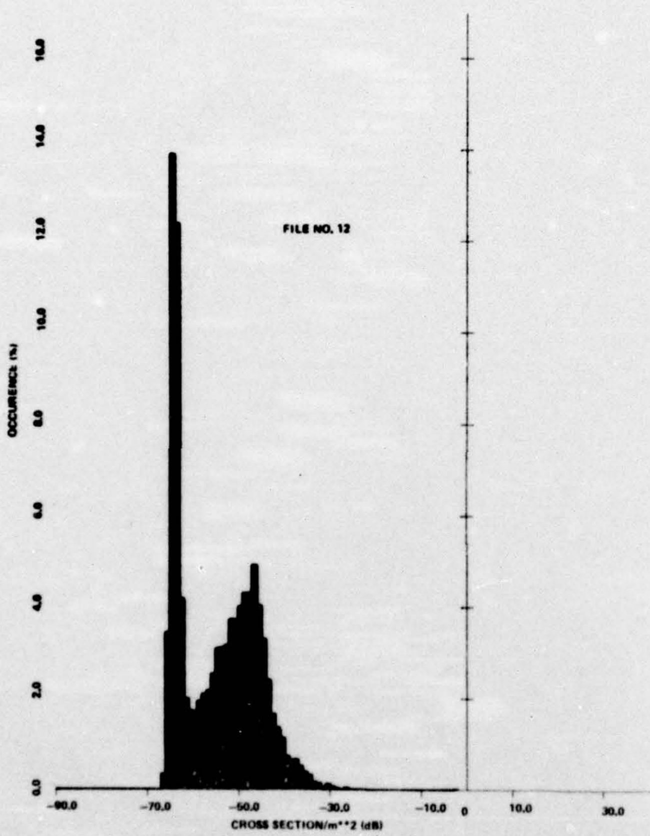


Figure 12b. Intensity dissec

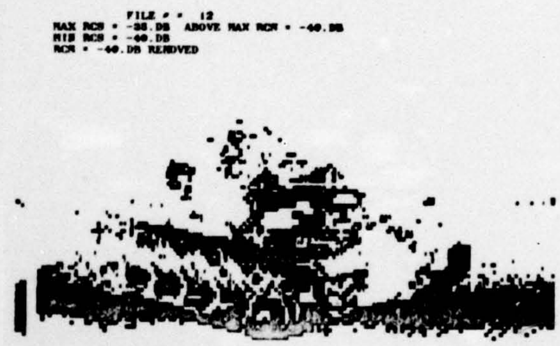


12b. Intensity dissection of image.

2



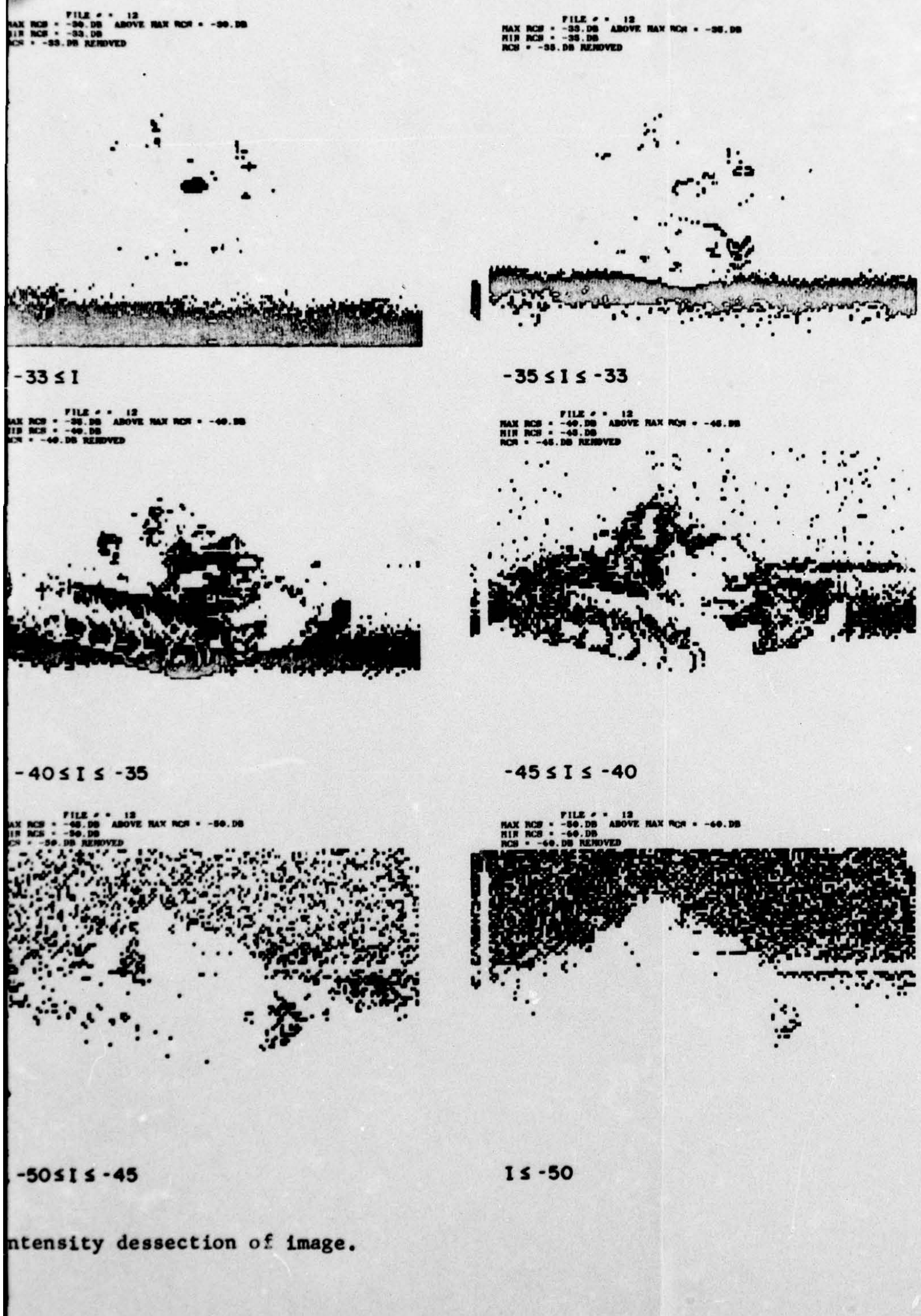
-33 ≤ I



-40 ≤ I ≤ -35

-50 ≤ I ≤ -45

Figure 12c. Intensity dessection of image.



ntensity dessection of image.

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Appendix A. INDEX OF DATA TAPE

In the data index which follows, information will be provided to aid the user in selecting image data for evaluation:

1) A photograph of the target and its location with respect to the scanner.

2) A composite image obtained during the scan.

3) Calibration voltages and additional comments.

4) Histograms of the 3.2-mm and 10.6-μm data files and images produced using the digital data.

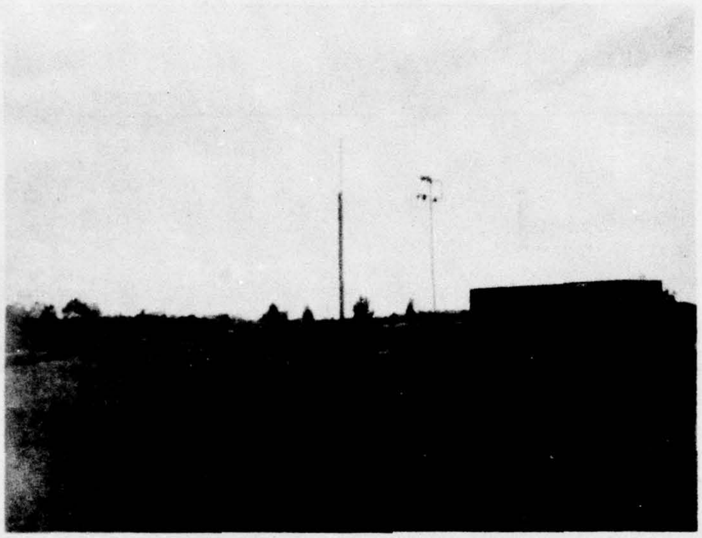
A summary of scans by target type is provided in Table A-1.

TABLE A-1. LIST OF THE TARGETS SCANS TAKEN

Target	Angle of View	3.2-mm Polarization*	Range (ft)	Tape and Scan No.	Notes
2-in. Ball	—	HH	51.5	27-1 and 2	
M48A5 Tank	Side	HH	50	27-3	
	45°	HH	50	27-4	
	Head	HH	50	27-5	
	Back	HH	50	27-6 and 8	
	Head	VH	50	29-2	Scanned after dark
	Side	VH	50	29-7	
	45°	VH	50	29-8	
	Back	VH	50	29-11	Light rain
	Side	VH	100	29-13	
	Side	HH	100	29-14	
	Side	HH	200	29-21	
	Side	HH	400	29-15 to 19	
2-1/2 Ton Truck with Canvas Top	Front	HH	50	28-5	Two vehicles in one scan
	Back				
	45°	HH	50	28-4	Includes water trailer
	Side	HH	50	28-3	Includes water trailer
	Side	VH	50	29-5	Includes water trailer, after dark
	Head	VH	50	29-9	Dark overcast
	Back	VH	50	29-12	
	Side	VH	100	29-13	
	Side	HH	100	29-14	
	Side	HH	200	29-21	
	Side	HH	400	29-15 to 19,20	
Jeeps with and without Rubberized Canvas	Head	HH	50	27-9	
	Back	HH	50	27-10	
	45°	HH	50	27-11	
	Side	HH	50	27-12	Includes trailer
	Side	VH	50	29-1	One jeep with trailer
	45°	VH	50	29-3	One jeep with trailer, after dark
	Front	VH	50	29-4	Two jeeps with trailer, after dark
	Back				
	Side	VH	100	29-13	
	Side	HH	100	29-14	
	Side	HH	400	29-15 to 19	
Jeep with Enclosed Cab	Side	HH	50	28-1	
2-1/2 Ton Truck with Wooden Side Rails	Side	HH	50	28-12	Rain
	Side	VH	50	29-6	After dark
2-1/2 Ton Field Kitchen with Trailer	Side	HH	50	28-14	Wooden enclosure on truck
Target panels (1.5 ft square)	Normal	HH	50	28-7	Six bare metal panels, night
	Normal	HH	50	28-8	Six bare metal panels, rain, double density data
	Normal	HH	50	28-10	Seven painted panels, rain, double density data
	Normal	HH	50	28-11	Seven painted panels, rain, normal density data
	20°	HH	50	28-13	Seven painted panels
NOTE: The following files are either partial scans or scans that are suspect due to temporary equipment problems.					
Tank	Back	HH	50	27-7	
2-1/2 Ton Truck	Side	HH	50	28-2	
Unknown Target				28-6	Not supplied on data tape
Tank	Back	VH	50	29-10	Not supplied on data tape
Test Panels	Normal	HH	50	28-9	Rain

*HH = Horizontal-Horizontal (parallel polarization)
HV = Horizontal-Vertical (cross polarization)

SCAN NO. 27–01 AND 27–02



TARGET: GOLD REFERENCE SPHERE

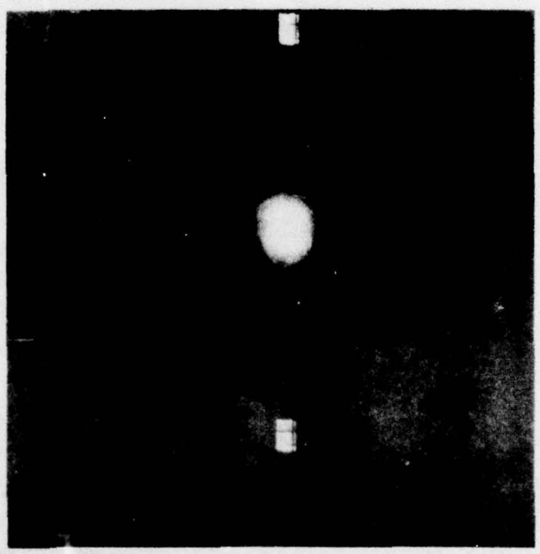
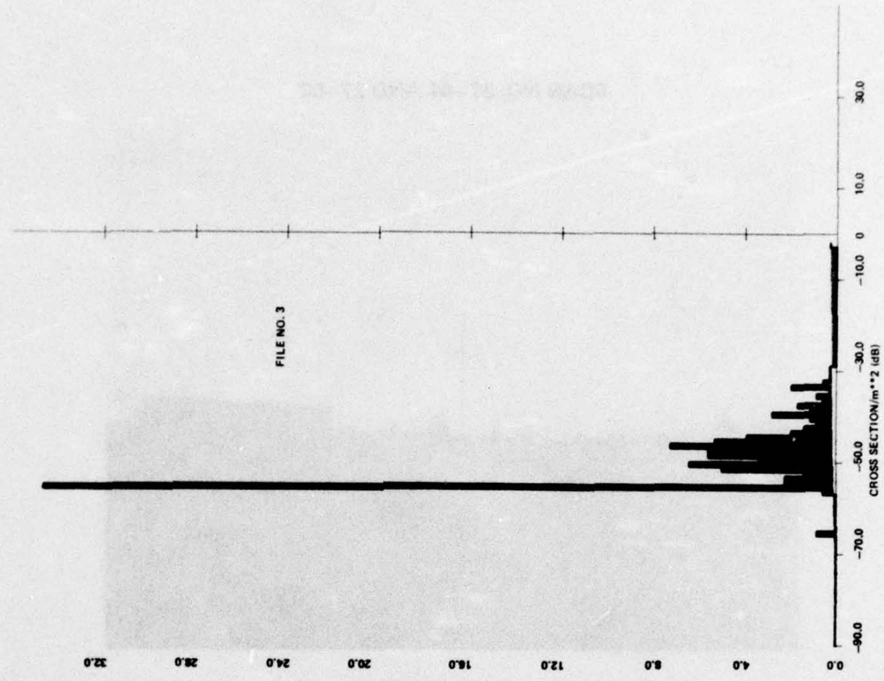
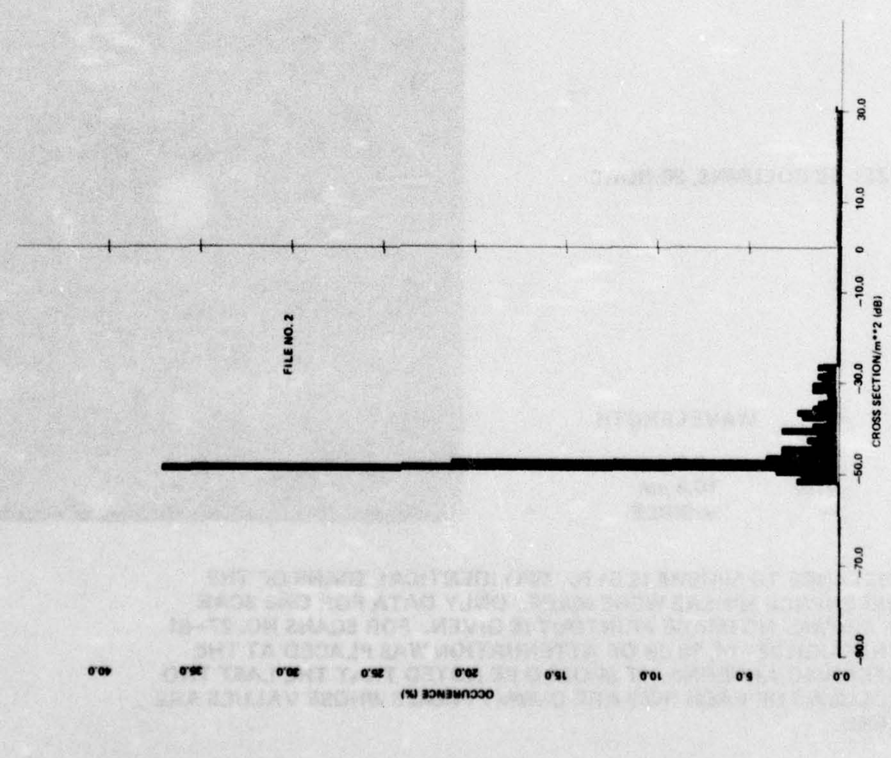


IMAGE SIZE: 18 COLUMNS, 20 ROWS

FILE NO.	V_s	WAVELENGTH
2.5	3.57	3.2 mm
3.6	7.34	10.6 μm
4.7	–	VISIBLE

NOTE: DISTANCE TO SPHERE IS 51 ft. TWO IDENTICAL SCANS OF THE REFERENCE SPHERE WERE MADE. ONLY DATA FOR ONE SCAN IS SHOWN. NO IMAGE PRINTOUT IS GIVEN. FOR SCANS NO. 27–01 THROUGH 28–14, 10 dB OF ATTENUATION WAS PLACED AT THE RECEIVER ANTENNA. IT SHOULD BE NOTED THAT THE LAST TWO COLUMNS OF EACH ROW ARE DUMMY PIXALS WHOSE VALUES ARE ZERO.


FILE NO. 3
CROSS SECTION/m**2 (dB)
OCCURENCE (%)


FILE NO. 2
CROSS SECTION/m**2 (dB)
OCCURENCE (%)

SCAN NO. 27–03

TARGET: M48 A5 TANK, SIDE VIEW

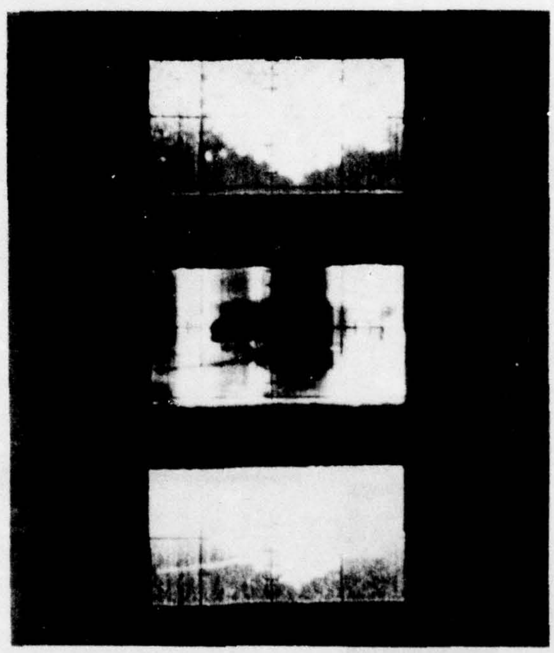
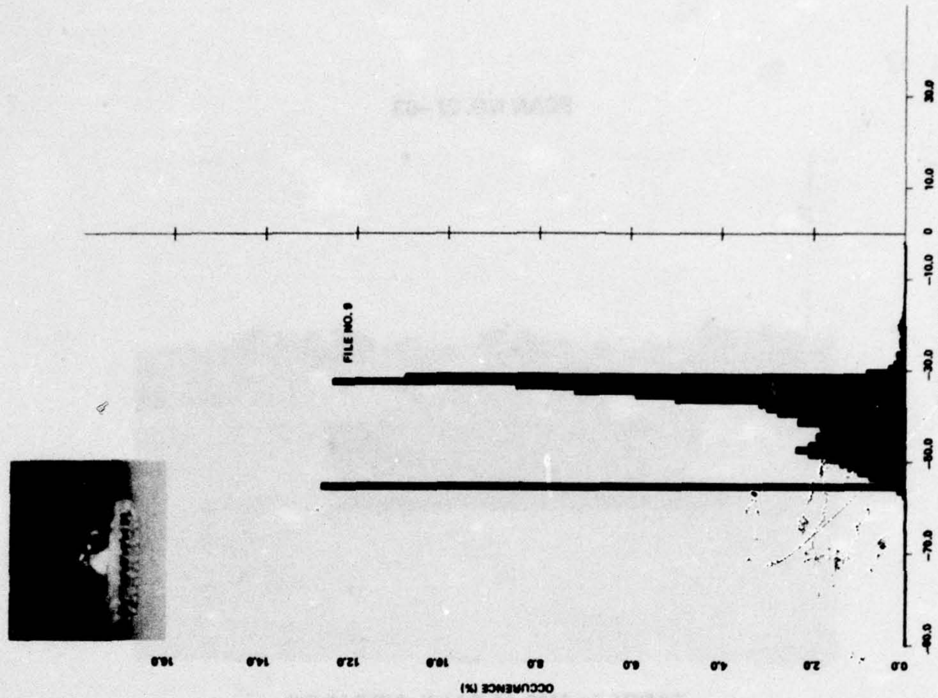
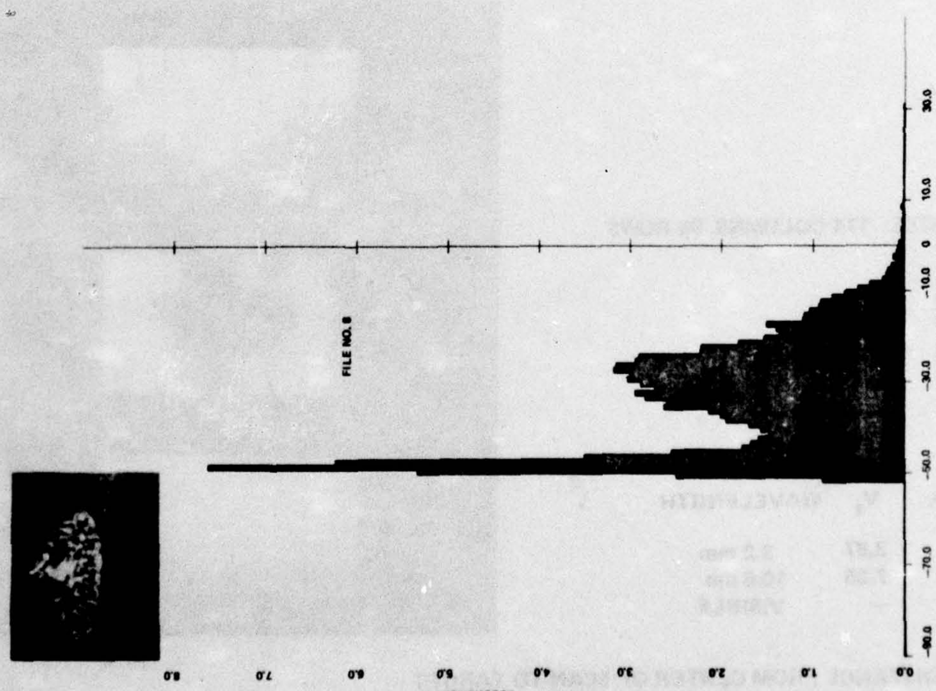


IMAGE SIZE: 174 COLUMNS, 96 ROWS

FILE NO.	V_s	WAVELENGTH
8	3.57	3.2 mm
9	7.35	10.6 μm
10	–	VISIBLE

NOTE: DISTANCE FROM CENTER OF SCAN TO TARGET
LEFT 51 ft CENTER 49 ft 5 in. RIGHT 50 ft 4 in.
VISIBLE SCAN IS STREAKED DUE TO CLOUDS


FILE NO. 9
OCCURENCE (%)
CROSS SECTION/m**2 (dB)


FILE NO. 8
OCCURENCE (%)
CROSS SECTION/m**2 (dB)

SCAN NO. 27–04

TARGET: M48A5 TANK, 45° VIEW

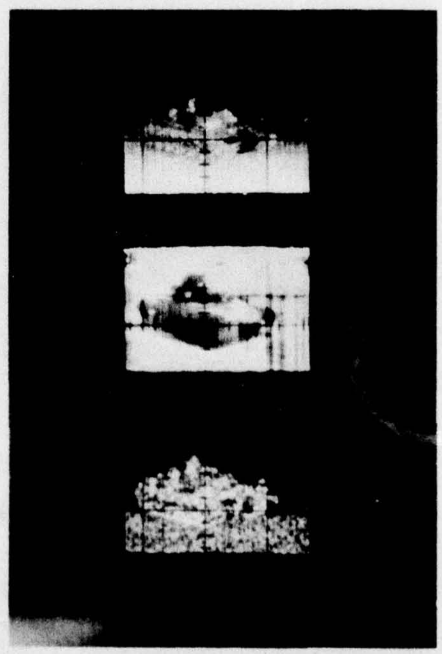
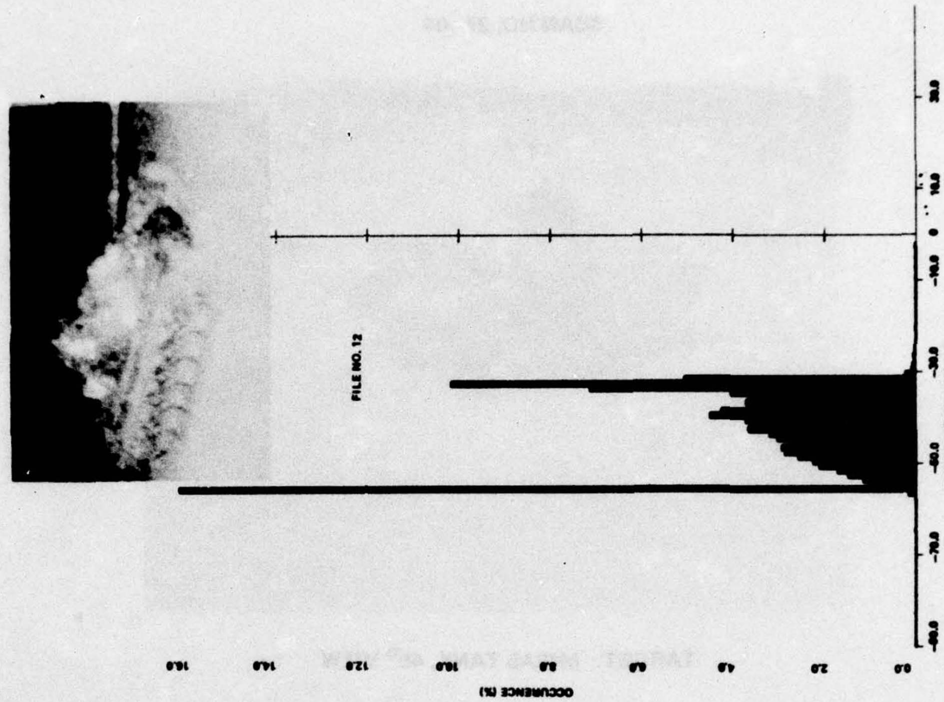


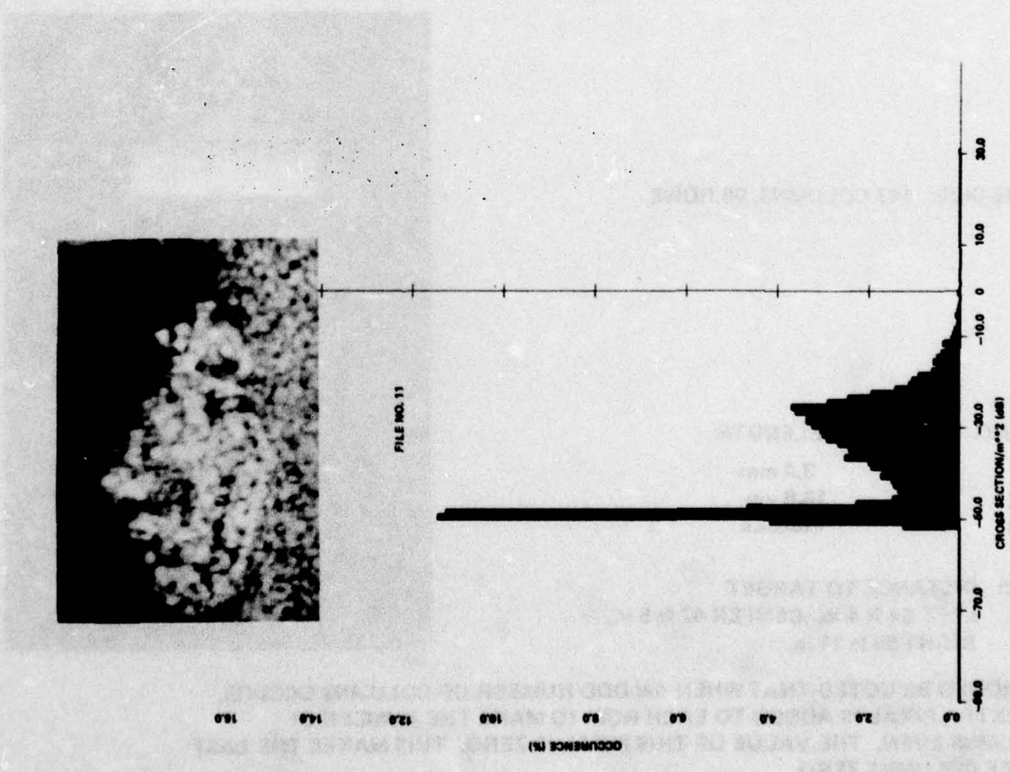
IMAGE SIZE: 147 COLUMNS, 98 ROWS

FILE NO.	V_s	WAVELENGTH
11	3.6	3.2 mm
12	7.35	10.6 μm
13	–	VISIBLE

NOTE: DISTANCE TO TARGET
LEFT 64 ft 4 in. CENTER 47 ft 5 in.
RIGHT 56 ft 11 in.

IT SHOULD BE NOTED THAT WHEN AN ODD NUMBER OF COLUMNS OCCURS, AN EXTRA PIXAL IS ADDED TO EACH ROW TO MAKE THE NUMCER OF COLUMNS EVEN. THE VALUE OF THIS PIXAL IS ZERO. THIS MAKES THE LAST THREE COLUMNS ZERO.


FILE NO. 12
CROSS SECTION/m**2 (dB)
OCCURENCE (%)


FILE NO. 11
CROSS SECTION/m**2 (dB)
OCCURENCE (%)

SCAN NO. 27–5

TARGET: M48A5 TANK, HEAD–ON

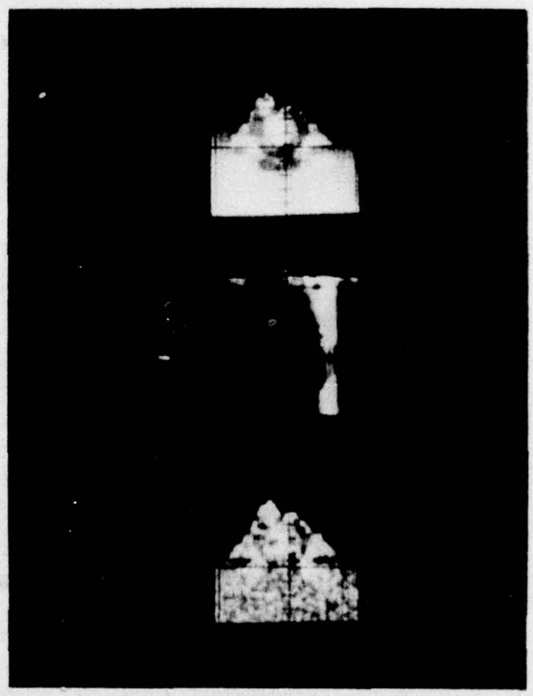
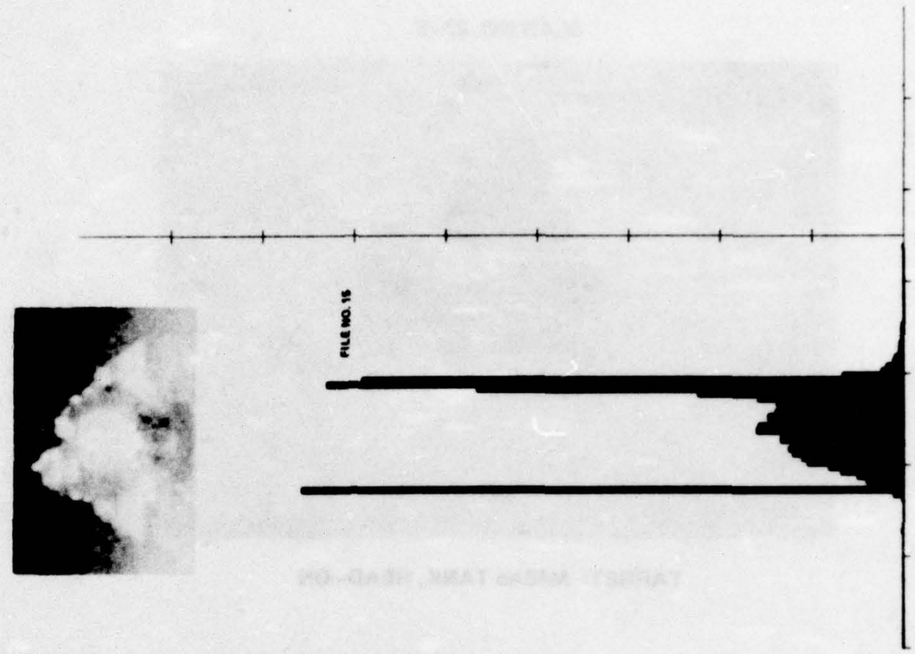


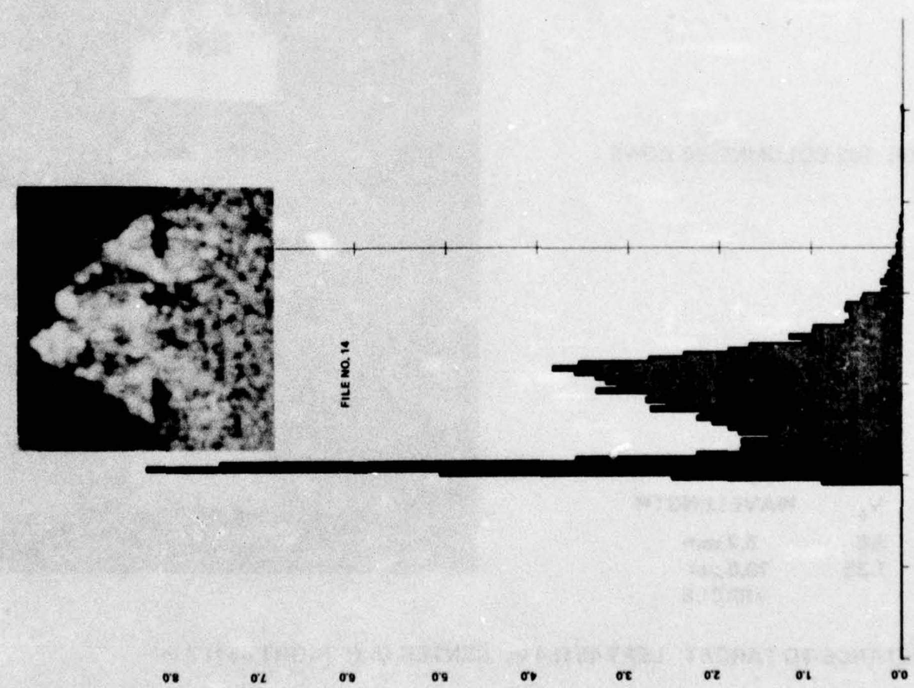
IMAGE SIZE: 102 COLUMNS, 96 ROWS

FILE NO.	V_s	WAVELENGTH
14	3.6	3.2 mm
15	7.35	10.6 μm
16		VISIBLE

NOTE: DISTANCE TO TARGET LEFT 45 ft 4 in. CENTER 45 ft RIGHT 45 ft 3 in.



FILE NO. 15
OCCURENCE (%)
CROSS SECTION/m**2 (dB)



FILE NO. 14
OCCURENCE (%)
CROSS SECTION/m**2 (dB)

SCAN NO. 27–6

BAD DATA

SCAN NO. 27–7

TARGET: M48A5 TANK, REAR VIEW

IMAGE SIZE: 99 COLUMNS, 98 ROWS

FILE NO.	V_s	WAVELENGTH
20	3.6	3.2 mm
21	7.35	10.6 μm
22	–	VISIBLE

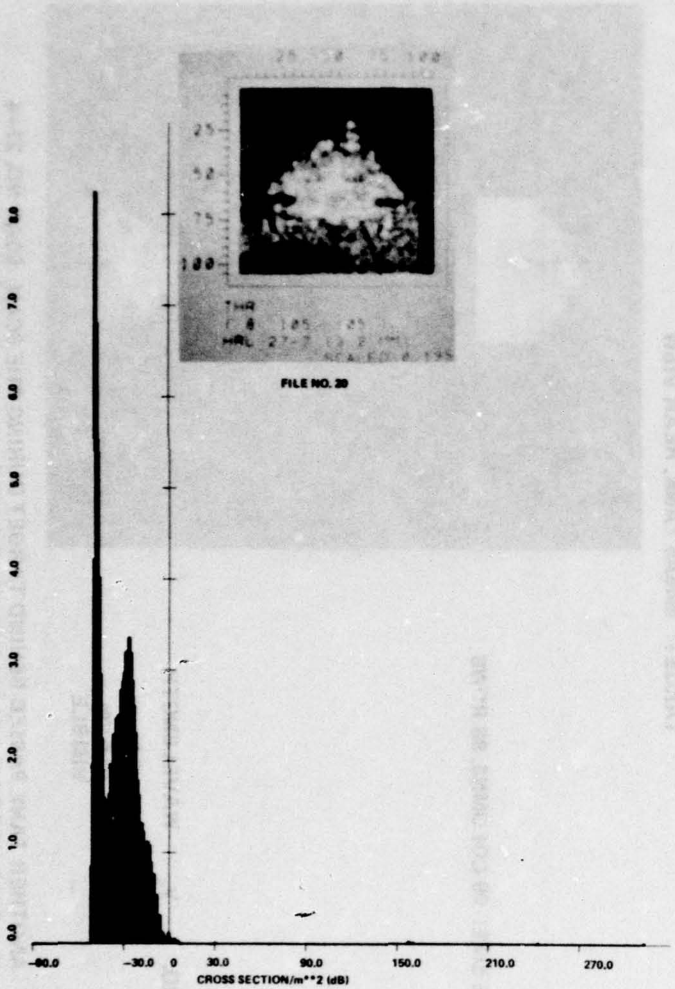
NOTE: ANOTHER TANK PASSED BEHIND TARGET DURING THE SCAN. SCAN NO. 27–8 IS A REPEAT OF THIS SCAN AND CAN BE USED FOR SPECKLE AVERAGING.

SCAN NO. 27–8

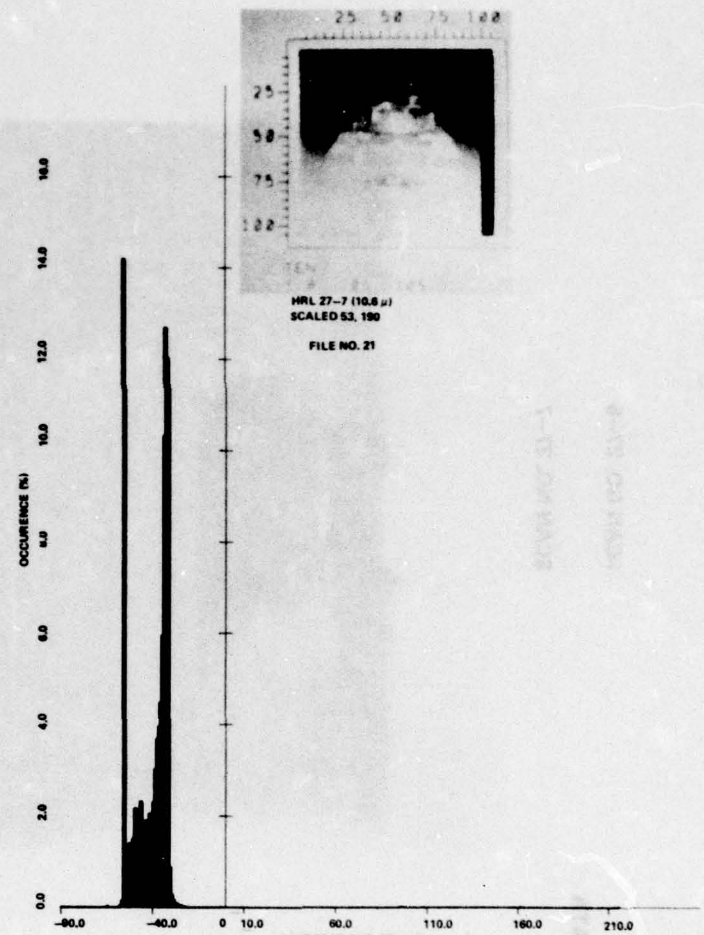
IMAGE SIZE: 90 COLUMNS, 98 ROWS

A REPEAT OF SCAN NO. 27–7. CALIBRATION VOLTAGES ARE IDENTICAL.

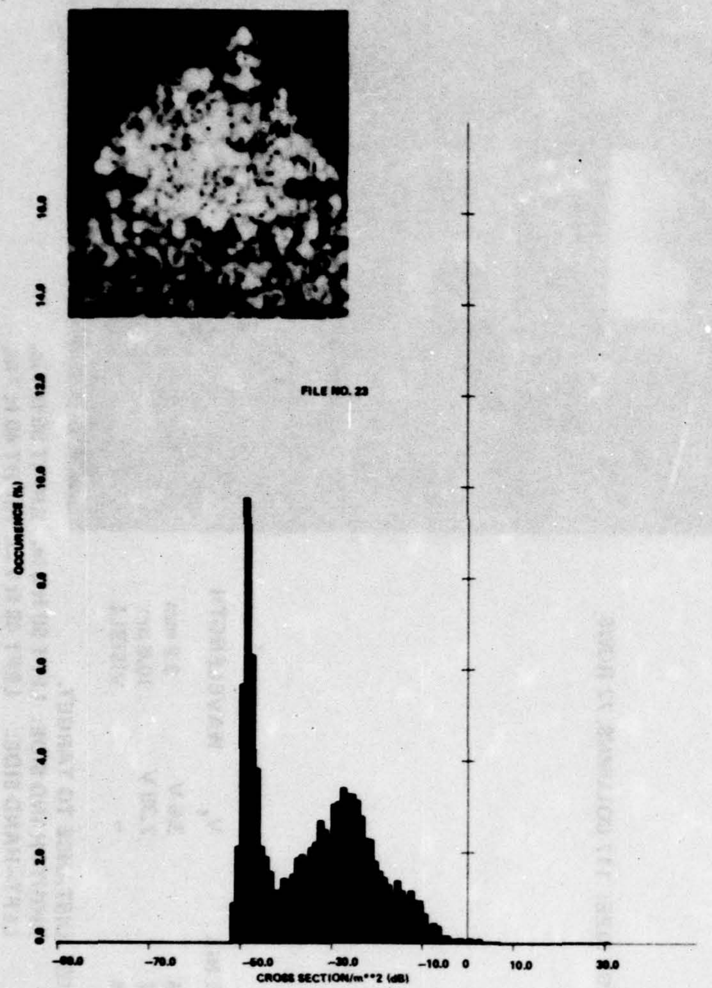
DISTANCE TO TARGET: LEFT 45 ft 1 in. CENTER 45 ft 4 in. RIGHT 45 ft 2 in.

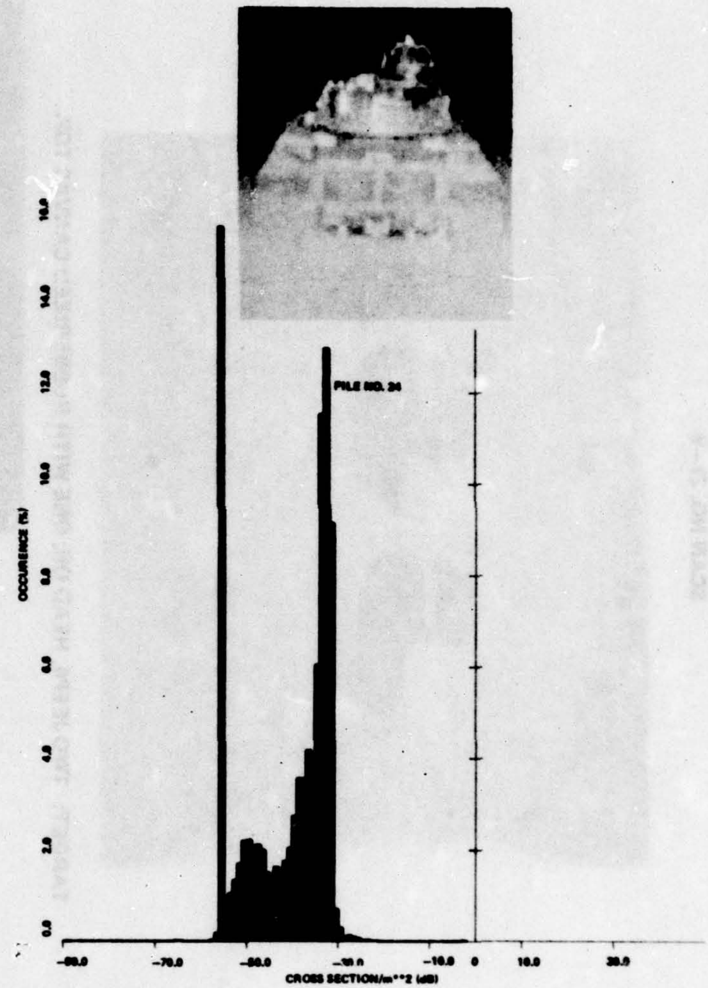


FILE NO. 20

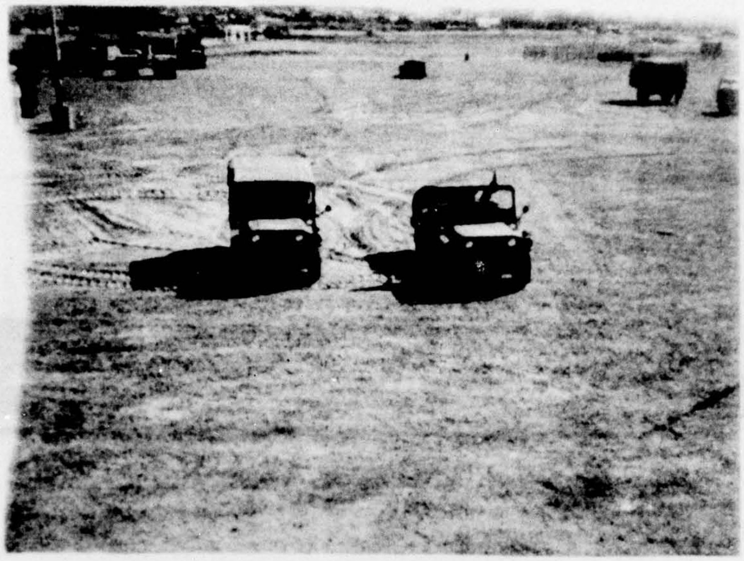


FILE NO. 21


FILE NO. 23
OCCURENCE (%)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
-80.0
-70.0
-50.0
-30.0
-10.0
0
10.0
30.0
CROSS SECTION/m**2 (dB)

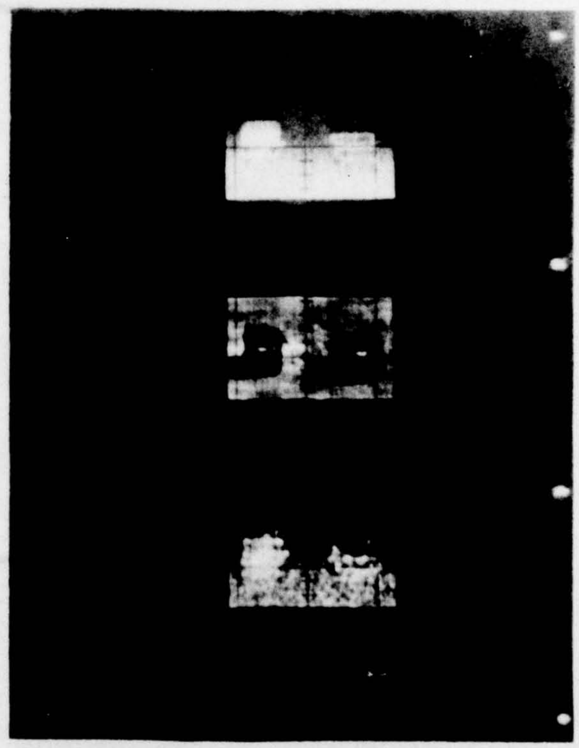

FILE NO. 24
OCCURENCE (%)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
-80.0
-70.0
-50.0
-30.0
-10.0
0
10.0
30.0
CROSS SECTION/m**2 (dB)

SCAN NO. 27–9



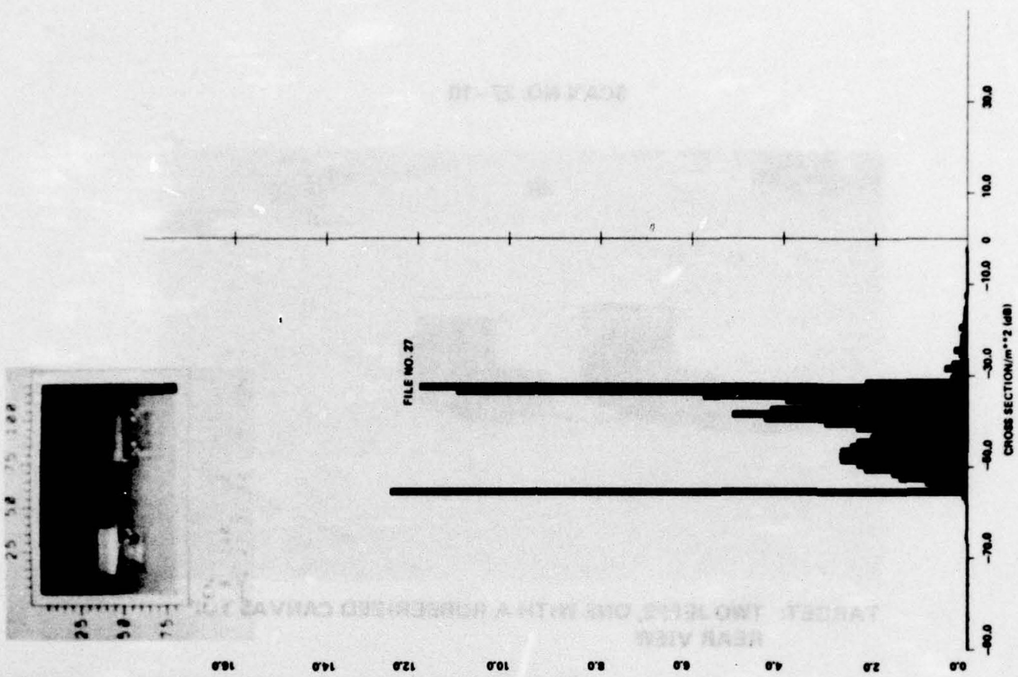
TARGET: TWO JEEPS, HEAD ON; ONE WITH RUBBERIZED CANVAS TOP.

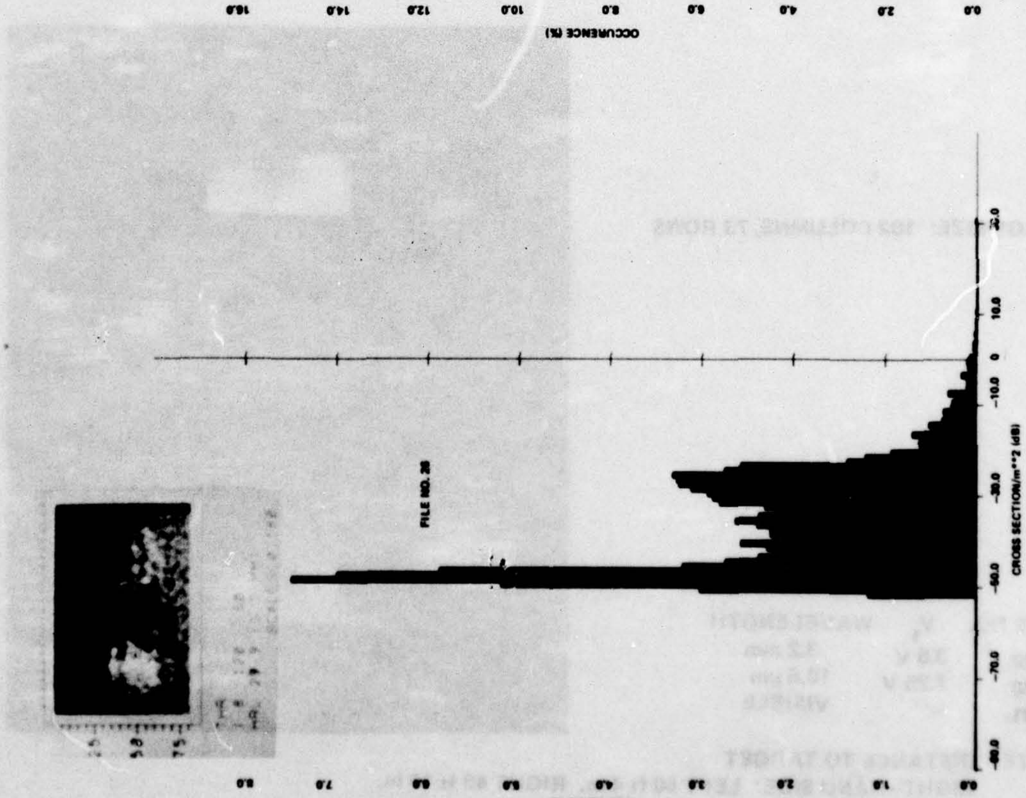
IMAGE SIZE: 117 COLUMNS, 72 ROWS



FILE NO.	V_s	WAVELENGTH
26	3.6 V	3.2 mm
27	7.35 V	10.6 μm
28	–	VISIBLE

NOTE: DISTANCE TO TARGET.
RIGHT–HAND SIDE: LEFT 50 ft 5 in. RIGHT 50 ft 4 in.
LEFT–HAND SIDE: LEFT 48 ft 7 in. RIGHT 49 ft 7 in.
FILE NO. 28 HAS A GOOD VISIBLE RECORD.


FILE NO. 27
CROSS SECTION/m**2 (dB)
OCCURENCE (%)
25 50 75 100


FILE NO. 28
CROSS SECTION/m**2 (dB)
OCCURENCE (%)

SCAN NO. 27–10

TARGET: TWO JEEPS, ONE WITH A RUBBERIZED CANVAS TOP
REAR VIEW

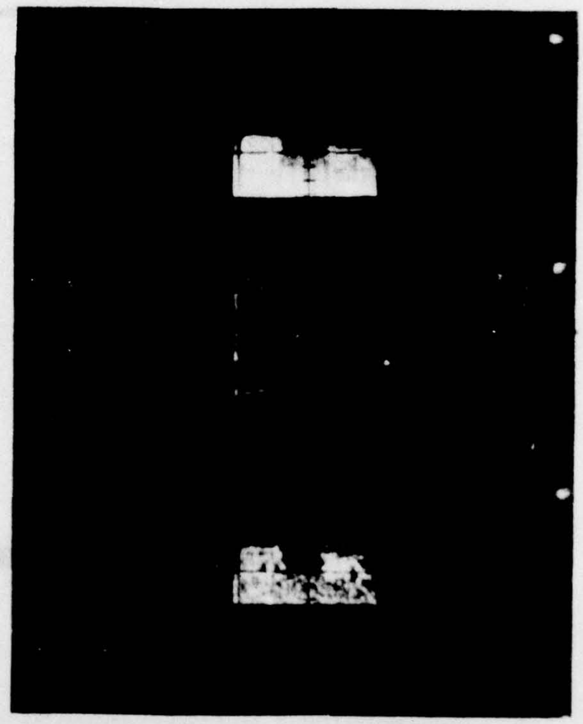
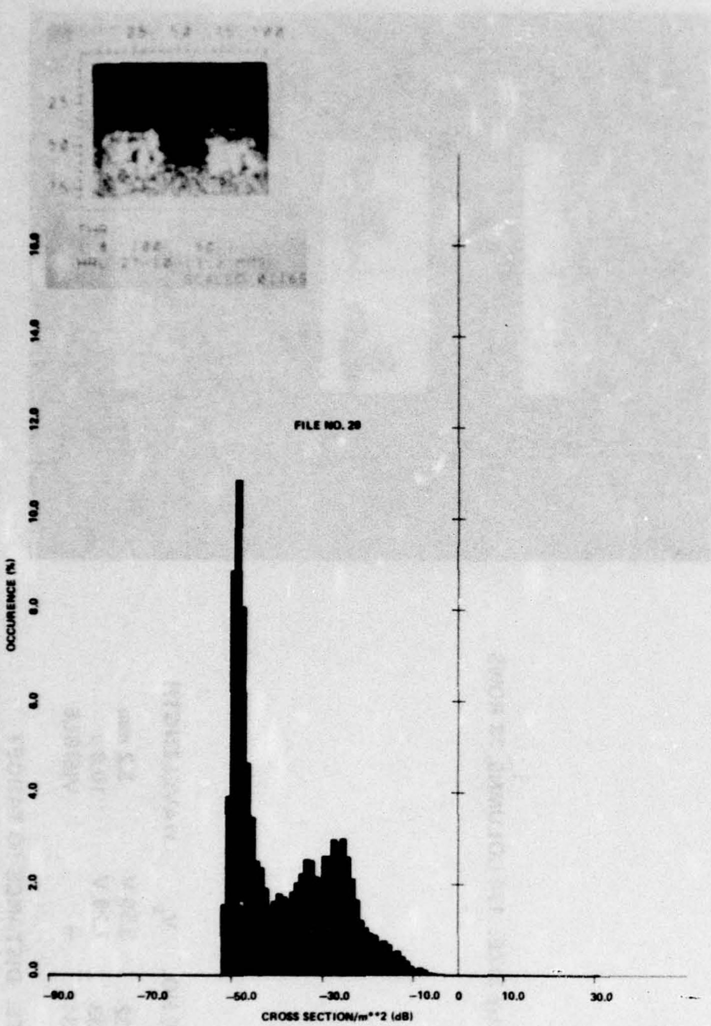


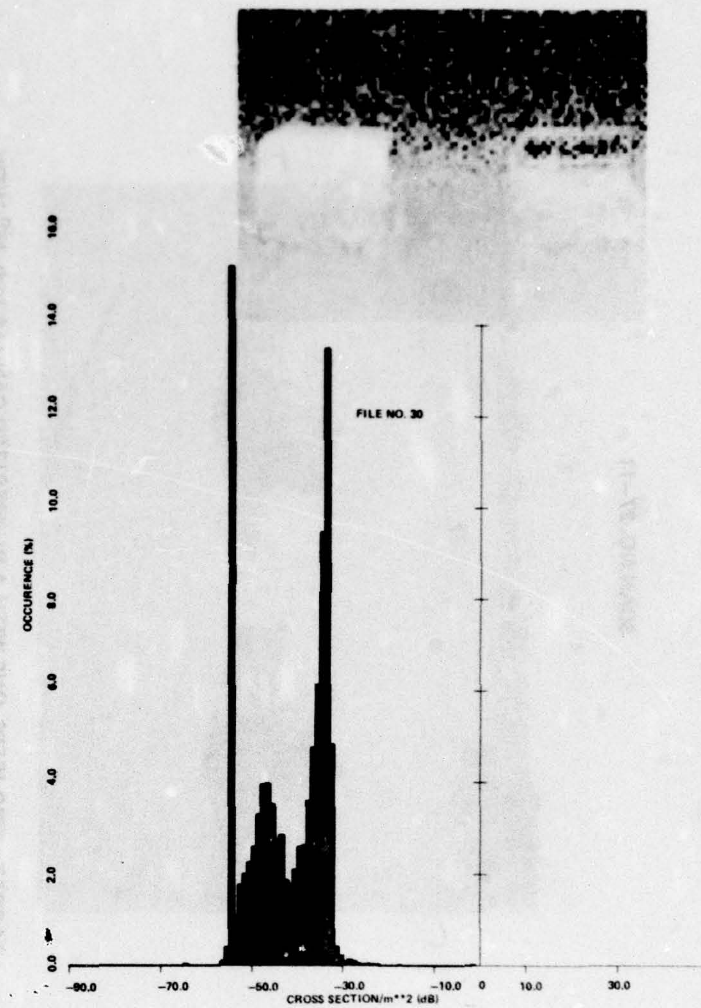
IMAGE SIZE: 102 COLUMNS, 73 ROWS

FILE NO.	V_s	WAVELENGTH
29	3.6 V	3.2 mm
30	7.25 V	10.6 μm
31	–	VISIBLE

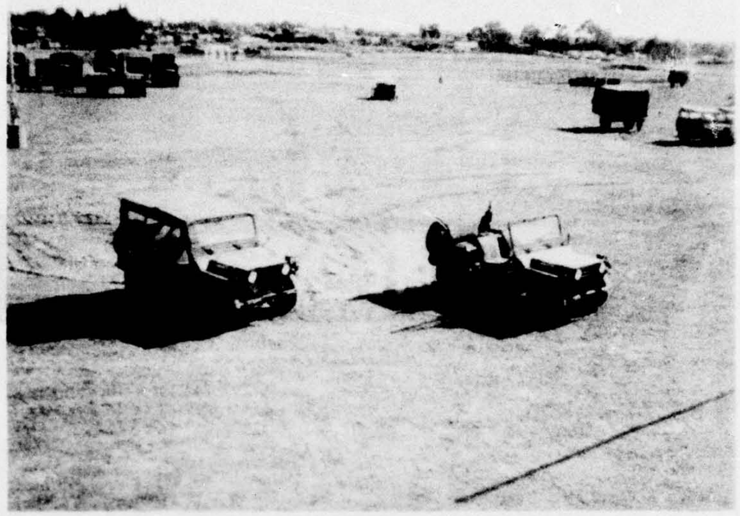
NOTE: DISTANCE TO TARGET
RIGHT–HAND SIDE: LEFT 50 ft 4 in. RIGHT 49 ft 10 in.
LEFT–HAND SIDE: LEFT 50 ft 7 in. RIGHT 50 ft 11 in.

FILE NO. 31 HAS A GOOD VISIBLE RECORD.


FILE NO. 29
OCCURENCE (%)
CROSS SECTION/m**2 (dB)


FILE NO. 30
OCCURENCE (%)
CROSS SECTION/m**2 (dB)

SCAN NO. 27–11



TARGET: TWO JEEPS, ONE WITH A RUBBERIZED CANVAS TOP, 45° VIEW

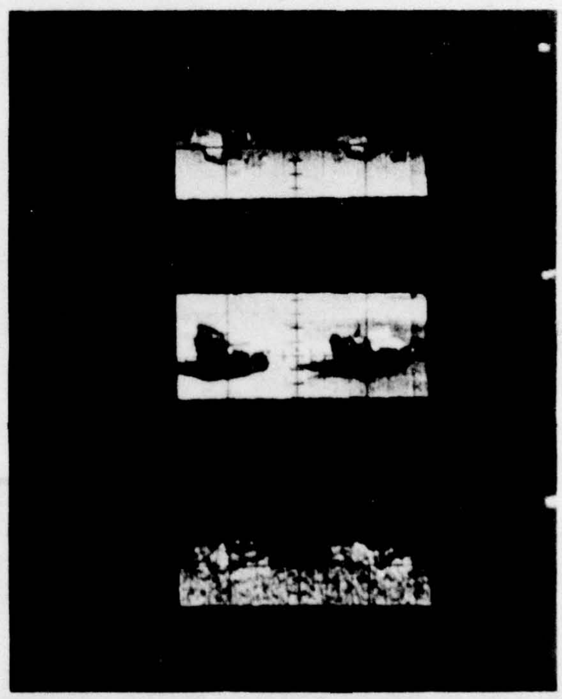
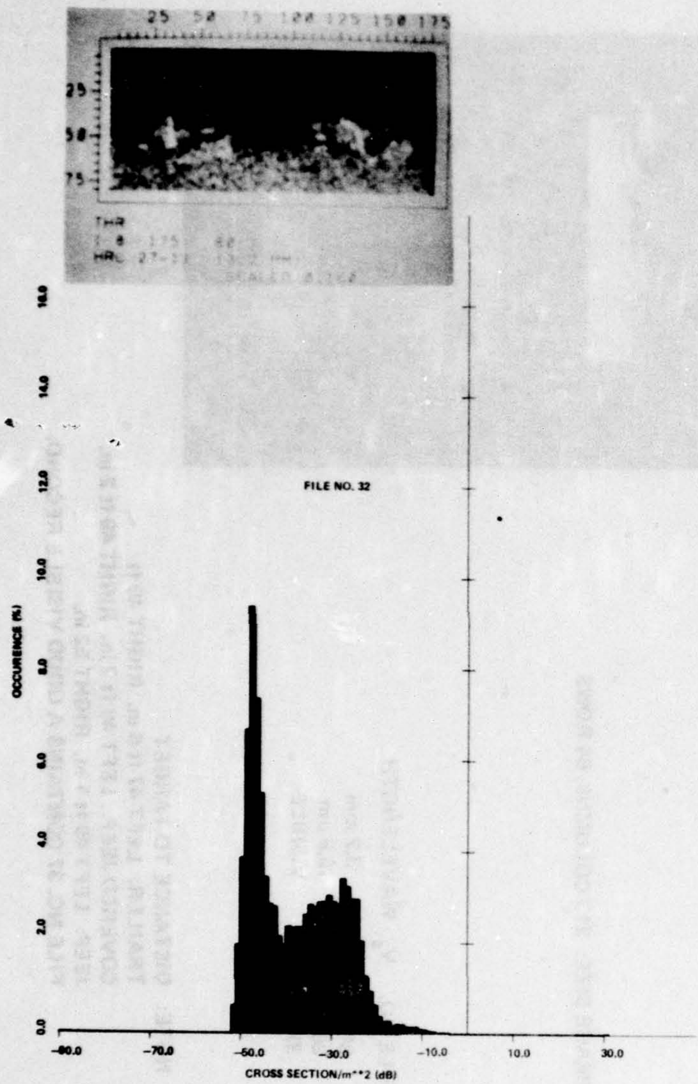


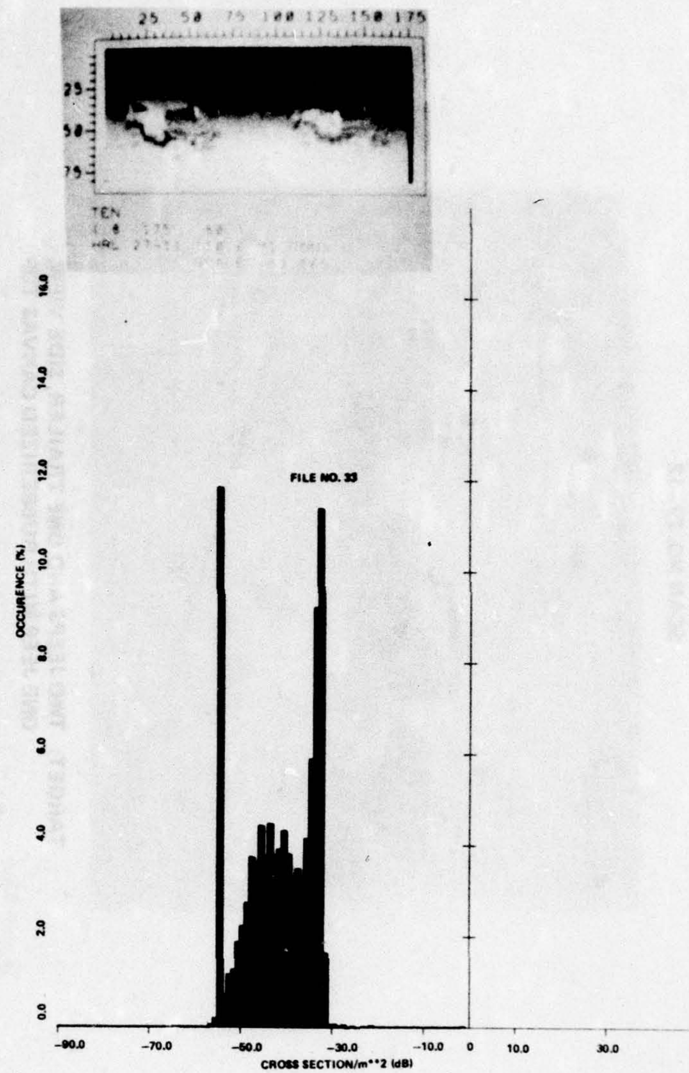
IMAGE SIZE: 174 COLUMNS, 73 ROWS

FILE NO.	V_s	WAVELENGTH
32	3.55 V	3.2 mm
33	7.20 V	10.6 μ
34	–	VISIBLE

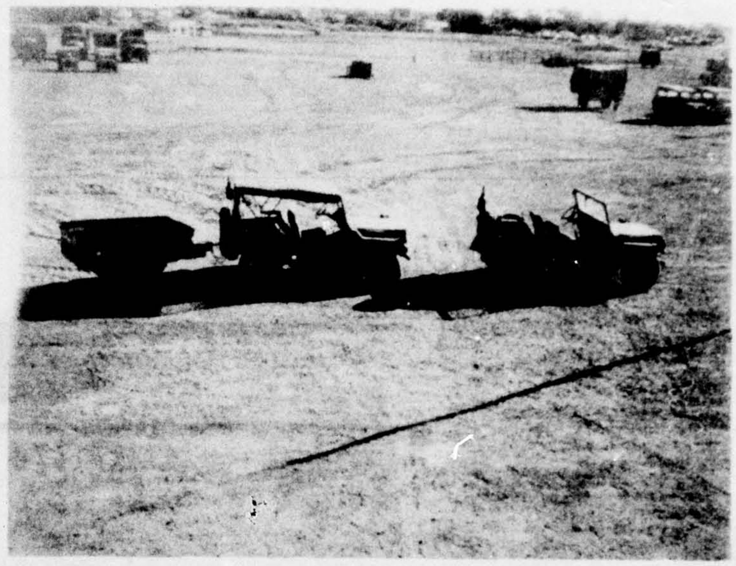
NOTE: DISTANCE TO TARGET
RIGHT–HAND SIDE: LEFT 56 ft 1 in. RIGHT 51 ft 7 in.
LEFT–HAND SIDE: LEFT 58 ft RIGHT 55 ft 4 in.

FILE NO. 34 HAS A GOOD VISIBLE RECORD.


FILE NO. 32
OCCURENCE (%)
CROSS SECTION/m**2 (dB)
-80.0
-70.0
-60.0
-30.0
-10.0
10.0
30.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
25 50 75 100 125 150 175
THR


FILE NO. 33
OCCURENCE (%)
CROSS SECTION/m**2 (dB)
-90.0
-70.0
-50.0
-30.0
-10.0
0
10.0
30.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
25 50 75 100 125 150 175
TEN

SCAN NO. 27–12



TARGET: TWO JEEPS AND ONE TRAILER, SIDE VIEW.
ONE JEEP WITH RUBBERIZED CANVAS TOP

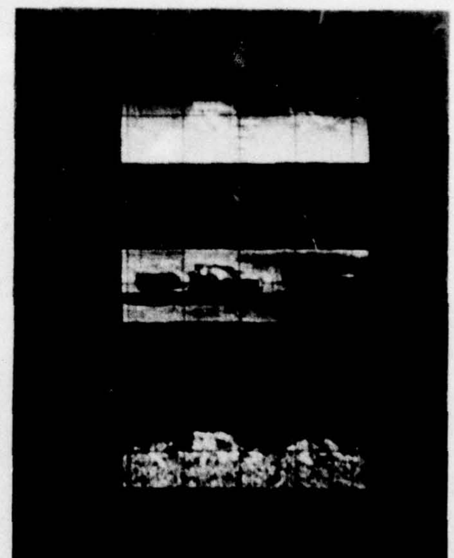
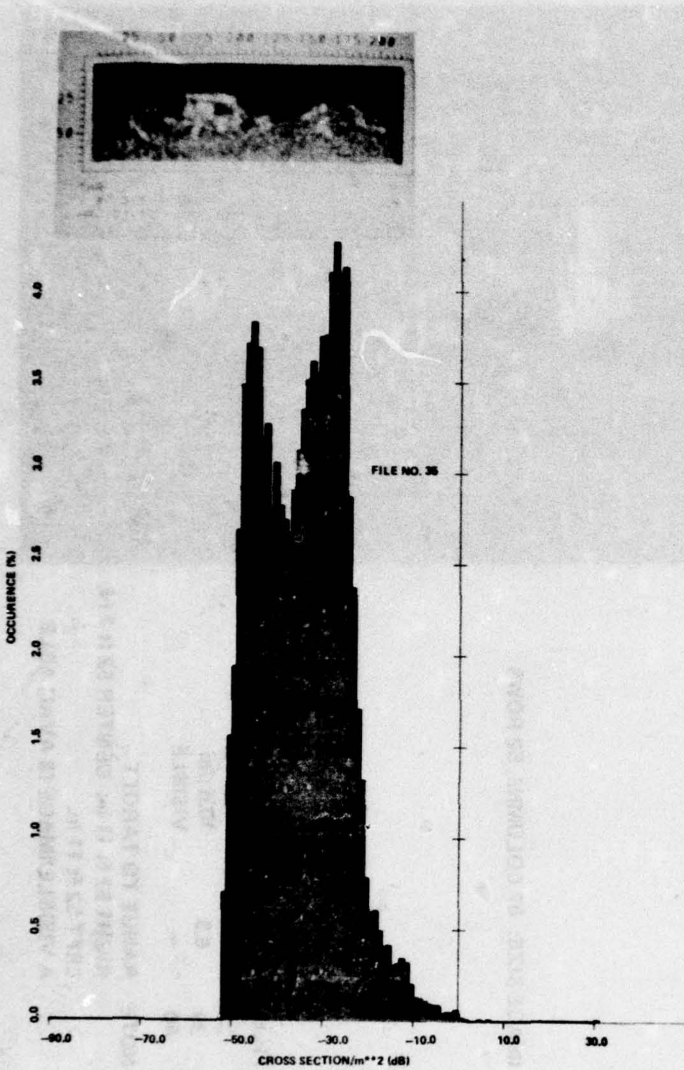
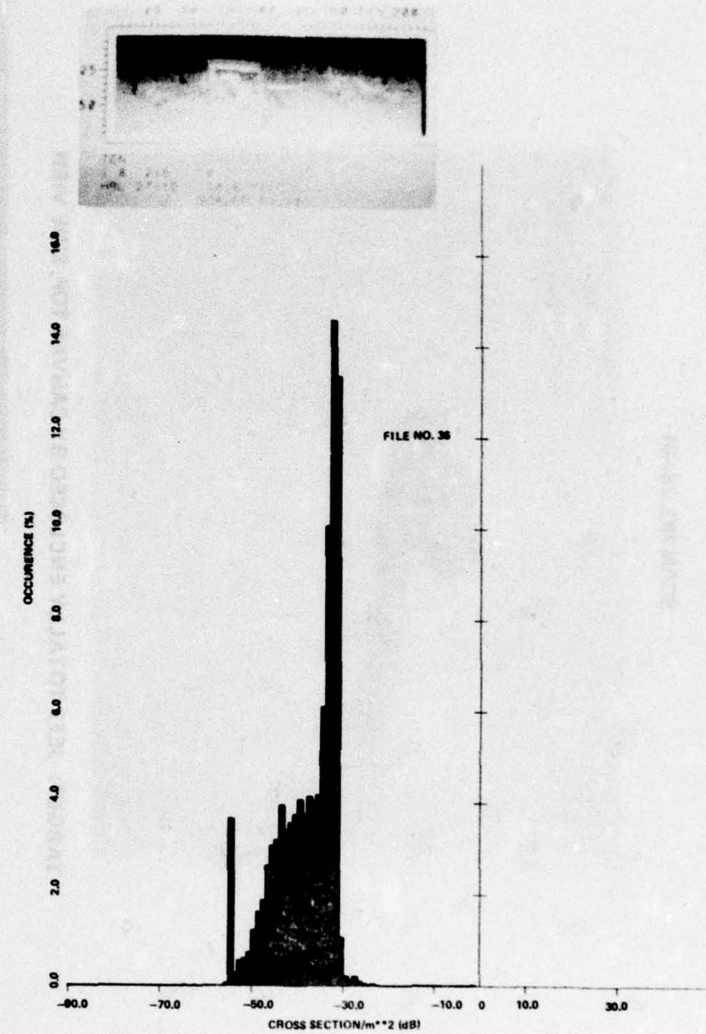


IMAGE SIZE: 213 COLUMNS, 64 ROWS

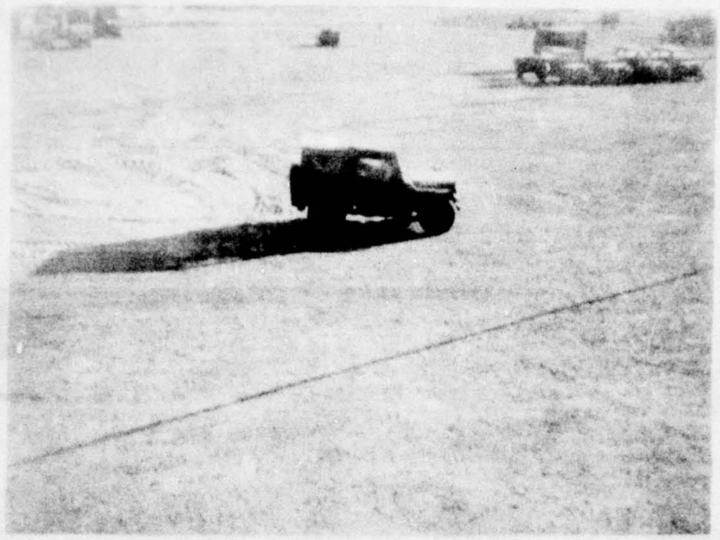
FILE NO.	V_s	WAVELENGTH
35	3.6	3.2 mm
36	7.15	10.6 μm
37	–	VISIBLE

NOTE: DISTANCE TO TARGET
TRAILER: LEFT 47 ft 6 in. RIGHT 49 ft
COVERED JEEP: LEFT 49 ft 2 in. RIGHT 49 ft 2 in.
JEEP: LEFT 49 ft 1 in. RIGHT 52 in.
FILE NO. 37 CONTAINS A GOOD VISIBLE RECORD.


FILE NO. 36
OCCURENCE (%)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
-90.0
-70.0
-50.0
-30.0
-10.0
10.0
30.0
CROSS SECTION/m**2 (dB)


FILE NO. 36
OCCURENCE (%)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
-90.0
-70.0
-50.0
-30.0
-10.0
0
10.0
30.0
CROSS SECTION/m**2 (dB)

SCAN NO. 28–01



TARGET: JEEP TOTALLY ENCLOSED BY CANVAS TOP, SIDE VIEW

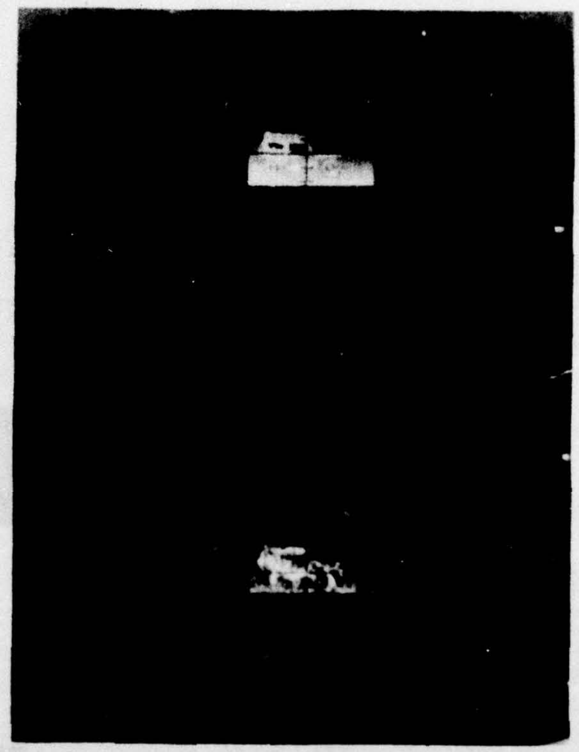


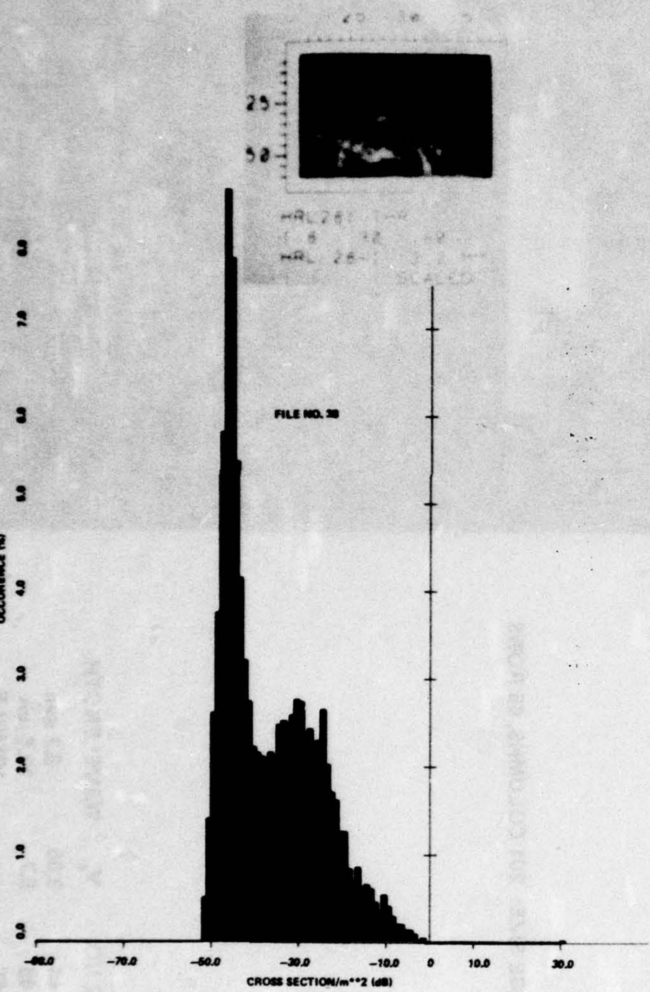
IMAGE SIZE: 87 COLUMNS, 52 ROWS

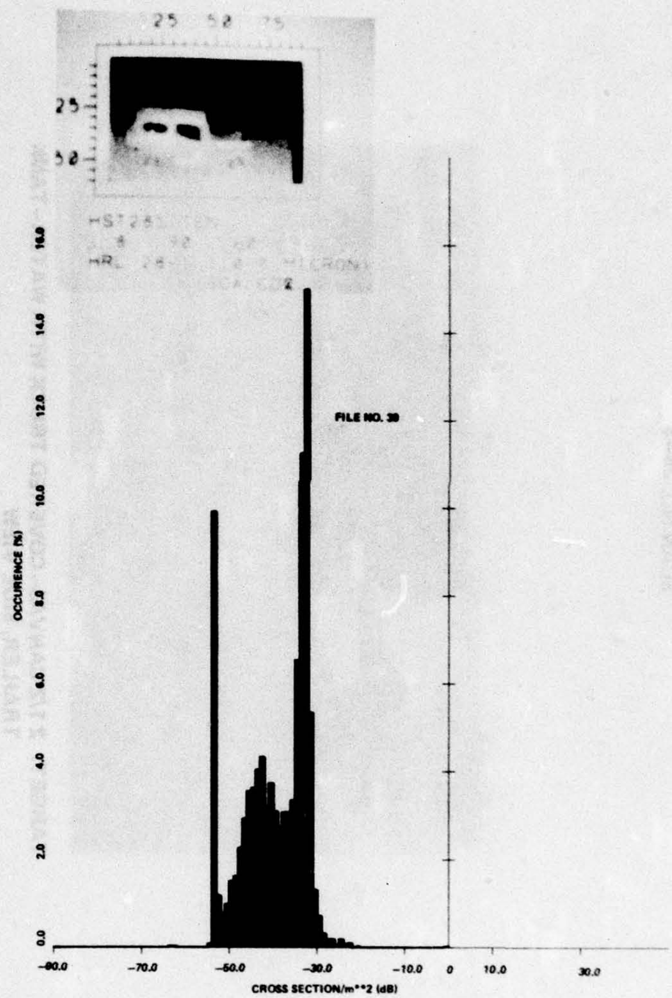
FILE NO.	V_s	WAVELENGTH
38	3.55	3.2 mm
39	6.9	10.6 μm
40	–	VISIBLE

NOTE: RANGE TO TARGET
RIGHT 52 ft 11 in. CENTER 52 ft 7 in.
LEFT 52 ft 11 in.
A VISIBLE IMAGE IS AVAILABLE

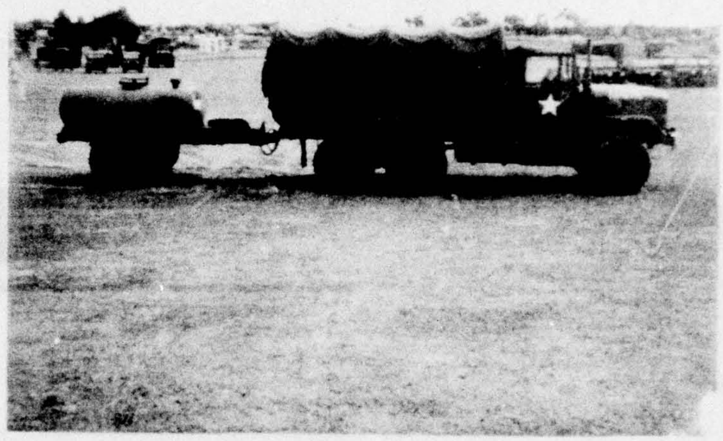
SCAN NO. 29–02

BAD FILE


OCCURENCE (%)
CROSS SECTION/m**2 (dB)


OCCURENCE (%)
CROSS SECTION/m**2 (dB)

SCAN NO. 28–3



TARGET: 2 1/2 CANVAS–COVERED TRUCK WITH WATER–TANK TRAILER, SIDE VIEW

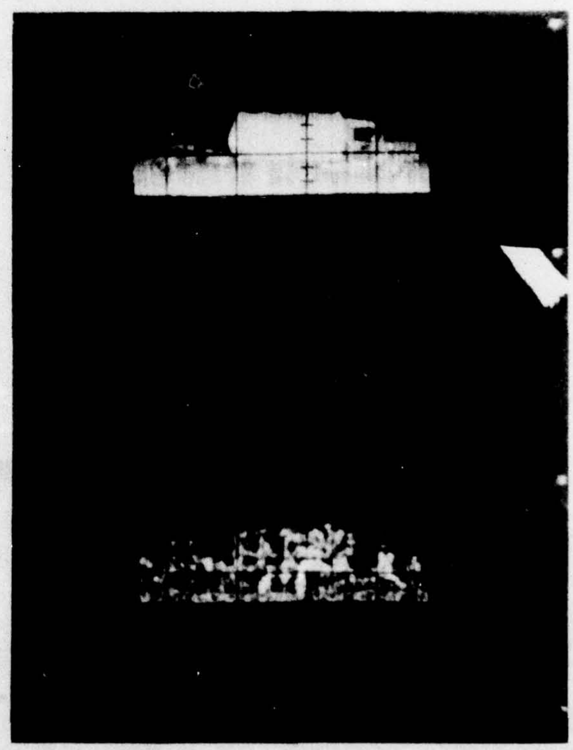
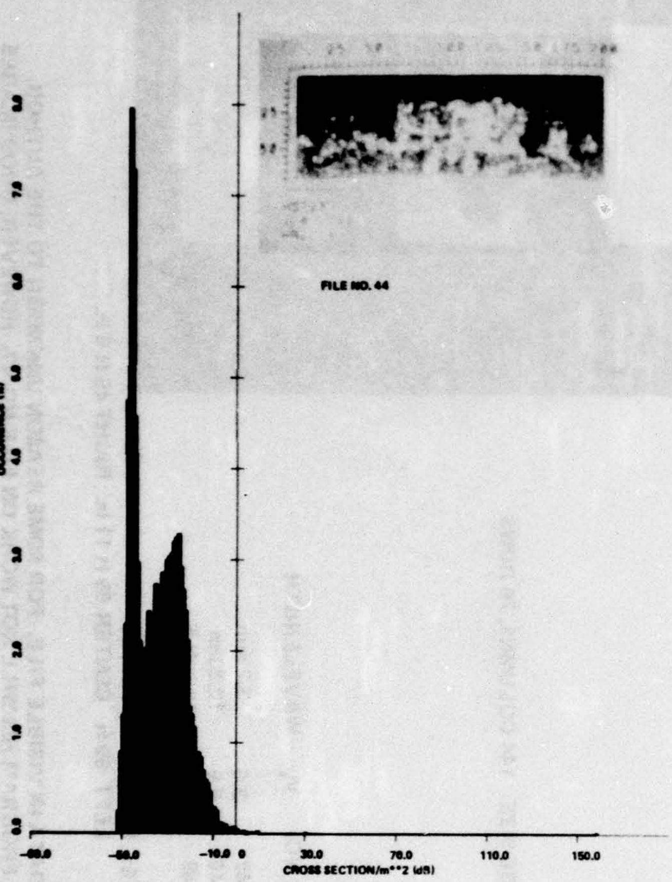
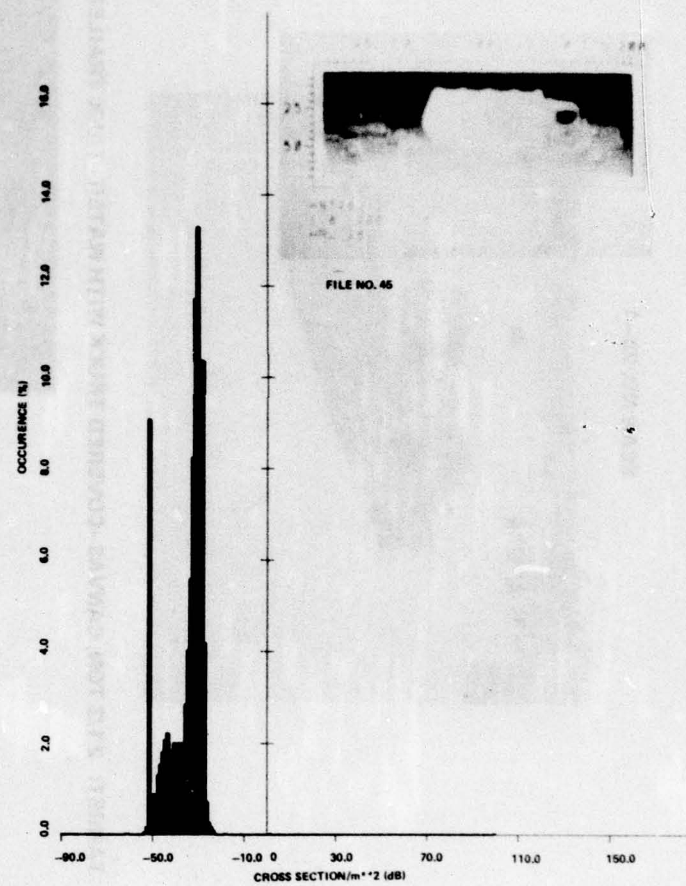


IMAGE SIZE: 201 COLUMNS, 65 ROWS

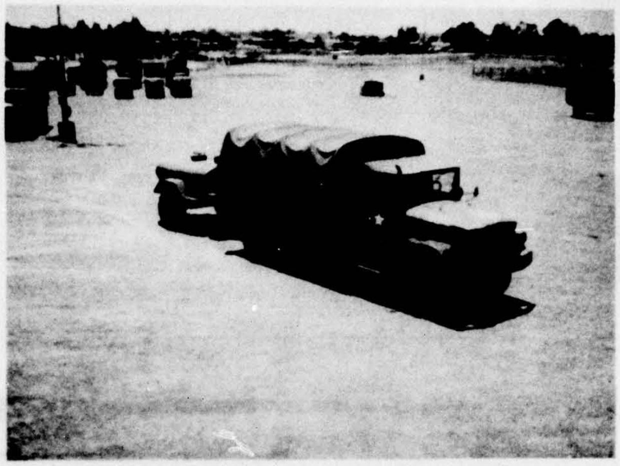
FILE NO.	V_s	WAVELENGTH
44	3.55	3.2 mm
45	6.7	10.6 μm
46	–	VISIBLE

NOTE: NO VISIBLE IMAGE.


FILE NO. 44
OCCURENCE (%)
CROSS SECTION/m**2 (dB)


FILE NO. 45
OCCURENCE (%)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
-90.0
-50.0
-10.0
0
30.0
70.0
110.0
150.0
CROSS SECTION/m**2 (dB)

SCAN NO. 28–4



TARGET: 2 1/2 TON, CANVAS–COVERED TRUCK WITH WATER–TANK TRAILER AT 45°

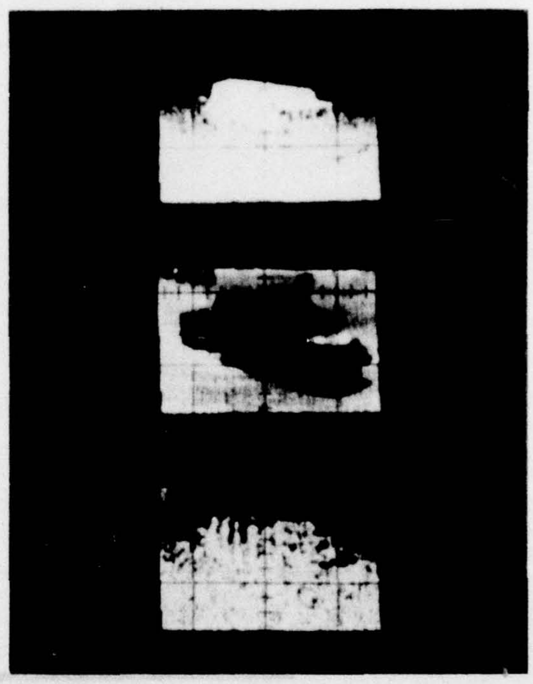
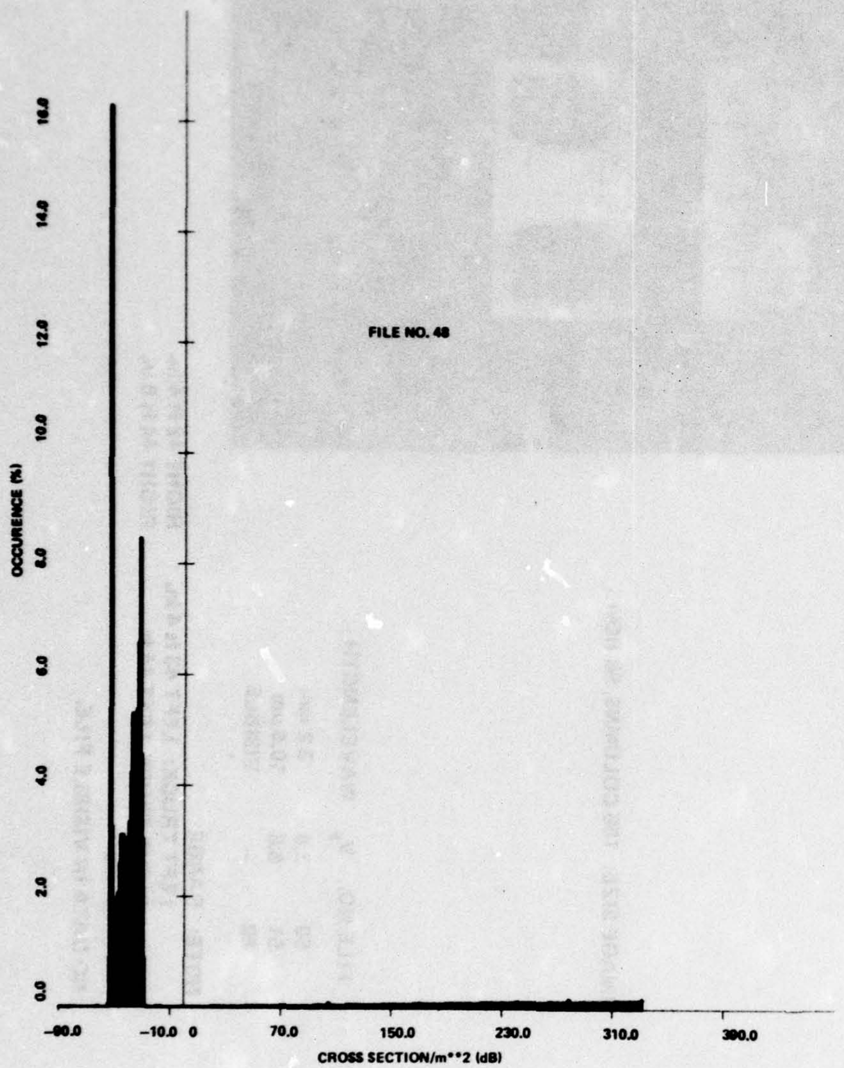


IMAGE SIZE: 144 COLUMNS, 76 ROWS

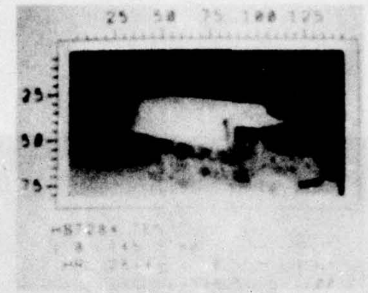
FILE NO.	V_s	WAVELENGTH
47	3.6	3.2 mm
48	6.9	10.6 μm
49	–	VISIBLE

NOTE: RANGE TO TARGET
LEFT 69 ft CENTER 65 ft 11 in. RIGHT 45 ft 6 in.

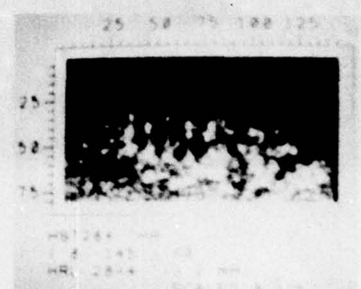
NO DATA IN VISIBLE FILE. FOR SOME REASON UNKNOWN TO THE AUTHOR, THE PROGRAM HIS WILL NOT WORK ON FILE NO. 47. HOWEVER, GOOD IMAGES CAN BE PRODUCED FROM THIS FILE



FILE NO. 48



FILE NO. 48



FILE NO. 47

SCAN NO. 28–5

TARGET: FRONT AND BACK VIEW OF 2 1/2 TON CANVAS– COVERED TRUCK

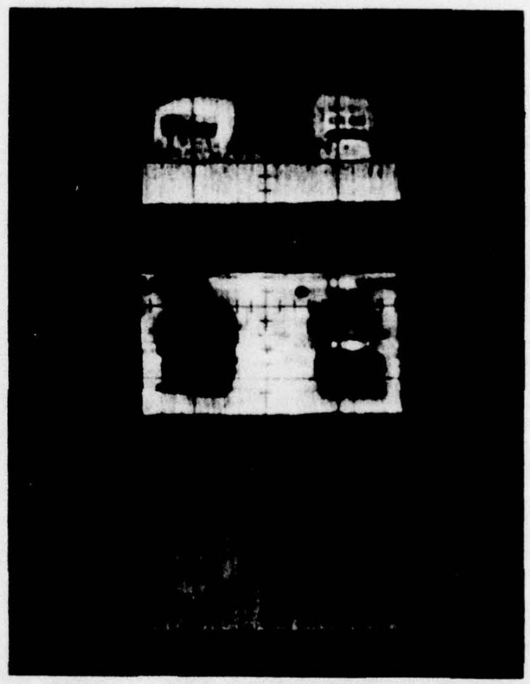
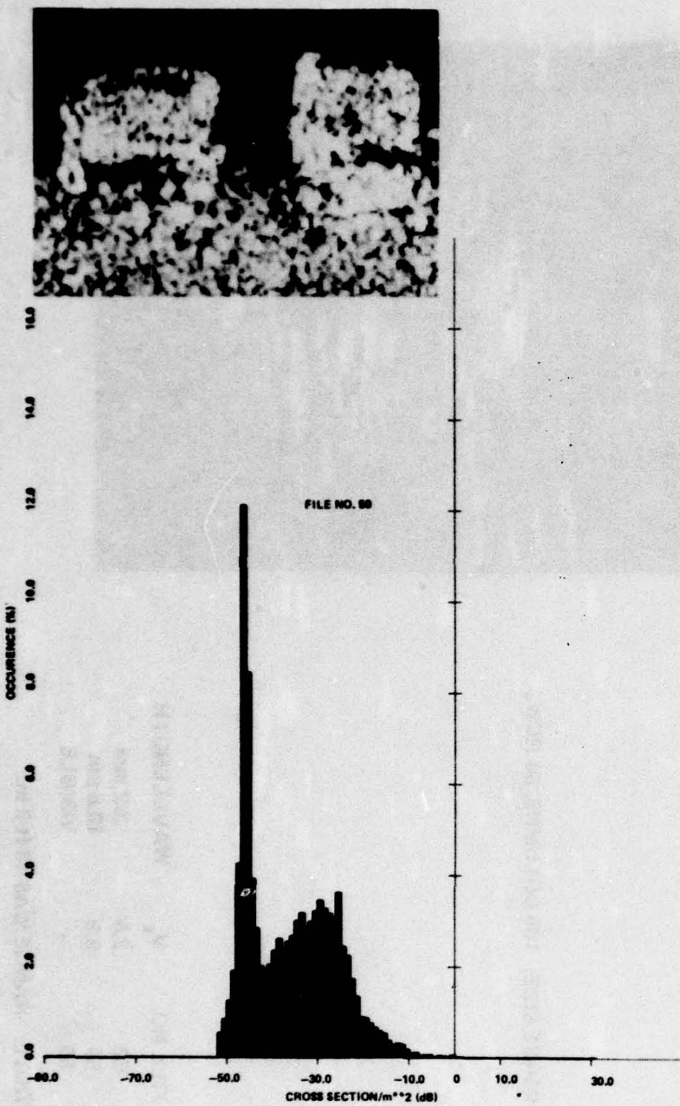


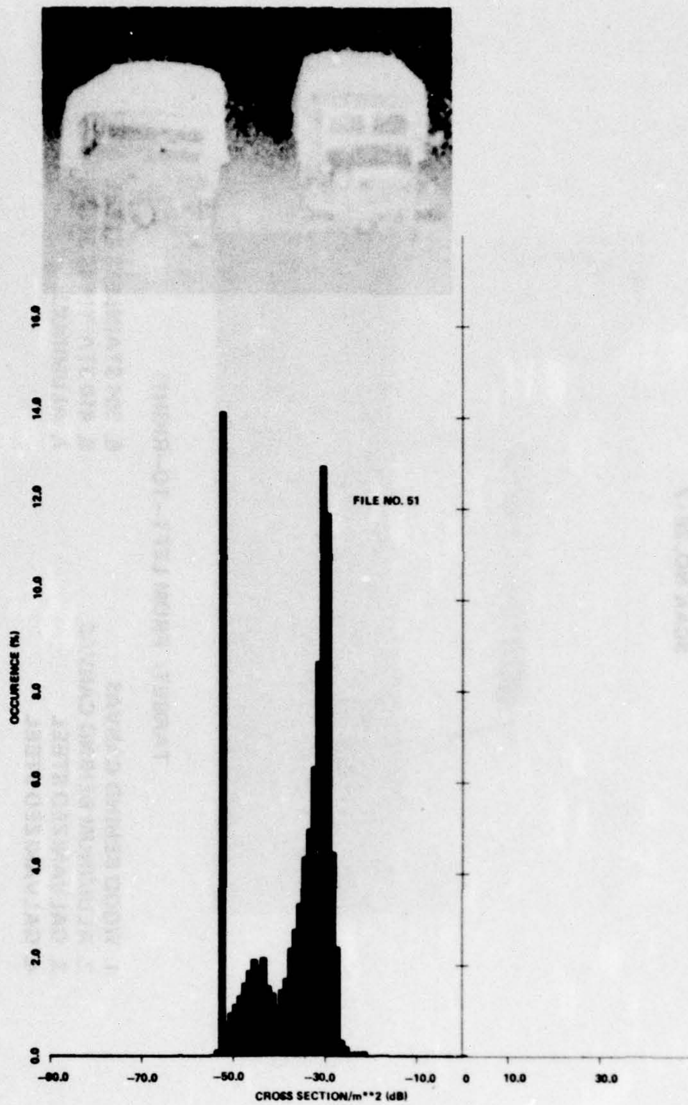
IMAGE SIZE: 156 COLUMNS, 98 ROWS

FILE NO.	V_s	WAVELENGTH
50	3.6	3.2 mm
51	6.8	10.6 μm
52	–	VISIBLE

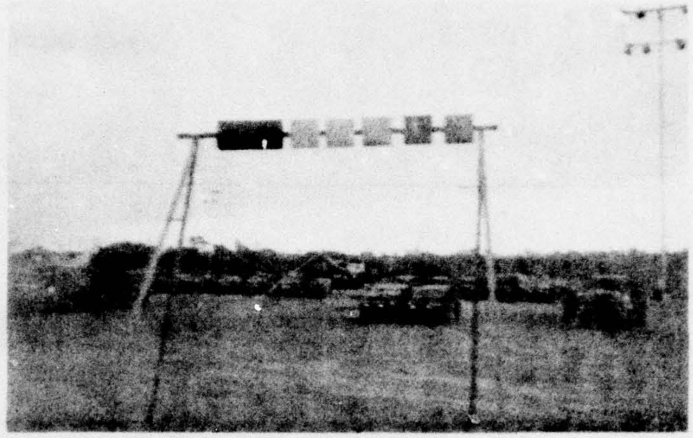
NOTE: RANGE
LEFT TRUCK: LEFT 43 ft 4 in. RIGHT 42 ft 4 in.
RIGHT TRUCK: LEFT 44 ft RIGHT 44 ft 8 in.

NO DATA IN VISIBLE FILE.


FILE NO.
OCCURENCE (%)
CROSS SECTION/m**2 (dB)
-80.0
-70.0
-50.0
-30.0
-10.0
0
10.0
30.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0


FILE NO. 51
OCCURENCE (%)
CROSS SECTION/m**2 (dB)
-80.0
-70.0
-50.0
-30.0
-10.0
0
10.0
30.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0

SCAN NO. 28–7



TARGET: FROM LEFT–TO–RIGHT:

1. WOOD BEHIND CANVAS
2. ALUMINUM BEHIND CANVAS
3. GALVANIZED STEEL
4. GALVANIZED STEEL
5. 304 STAINLESS STEEL
6. 410 STAINLESS STEEL
7. ALUMINUM

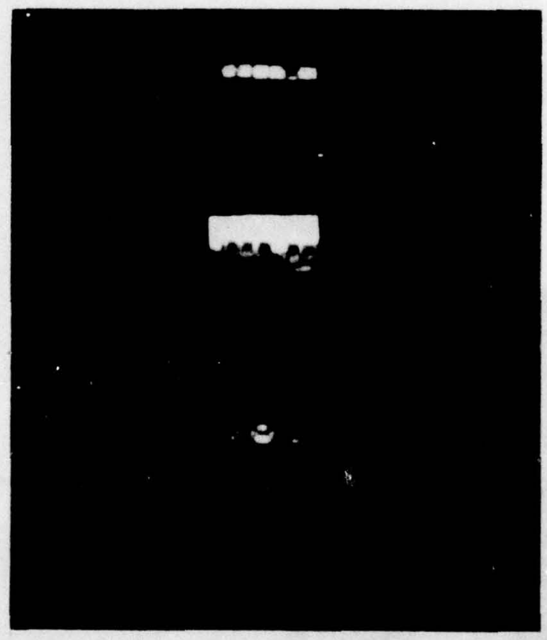
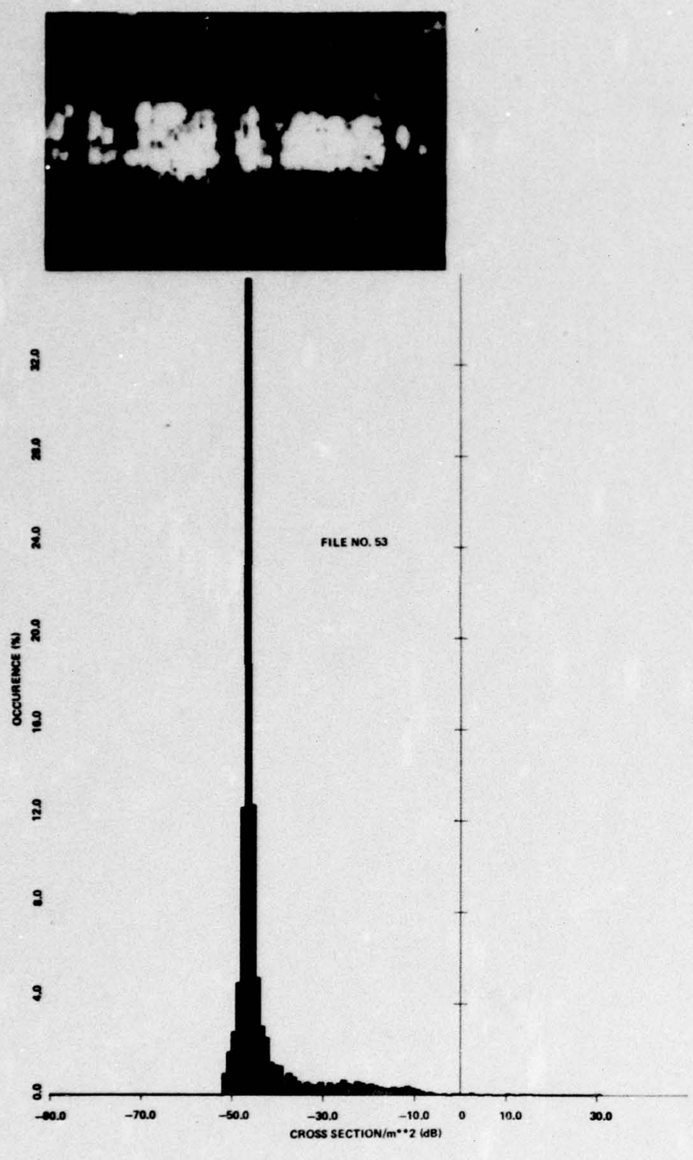
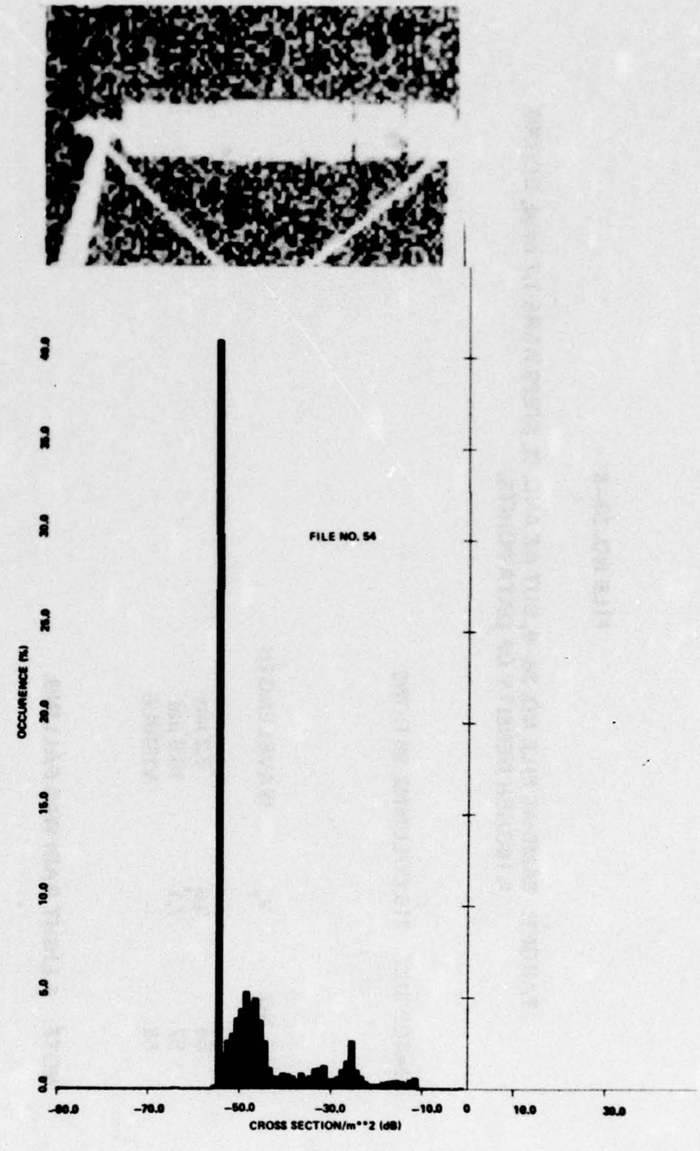


IMAGE SIZE: 108 COLUMNS, 64 ROWS

FILE NO.	V_s	WAVELENGTH
53	3.6	3.2 mm
54	6.8	10.6 μm
55	–	VISIBLE

NOTE: RANGE WAS 48 ft 2 in.


FILE NO. 53
OCCURENCE (%)
CROSS SECTION/m**2 (dB)


FILE NO. 54
OCCURENCE (%)
CROSS SECTION/m**2 (dB)

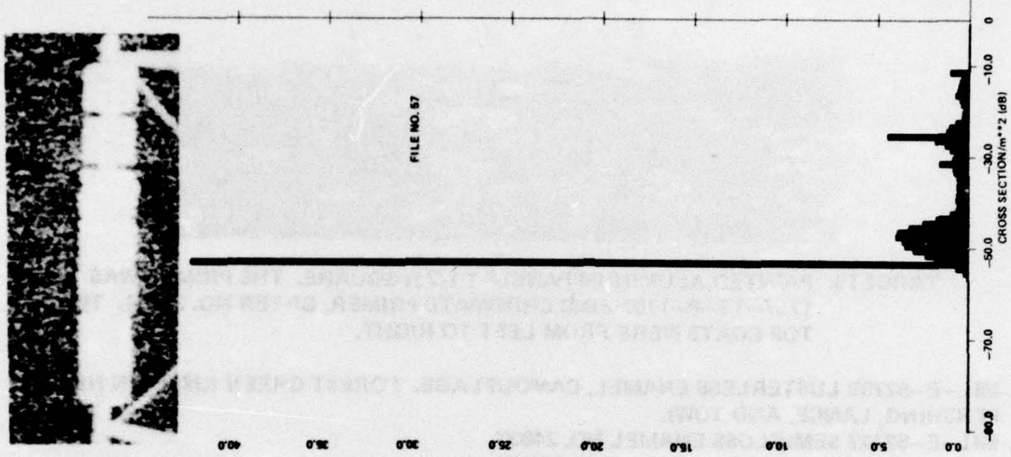
FILE NO. 28–8

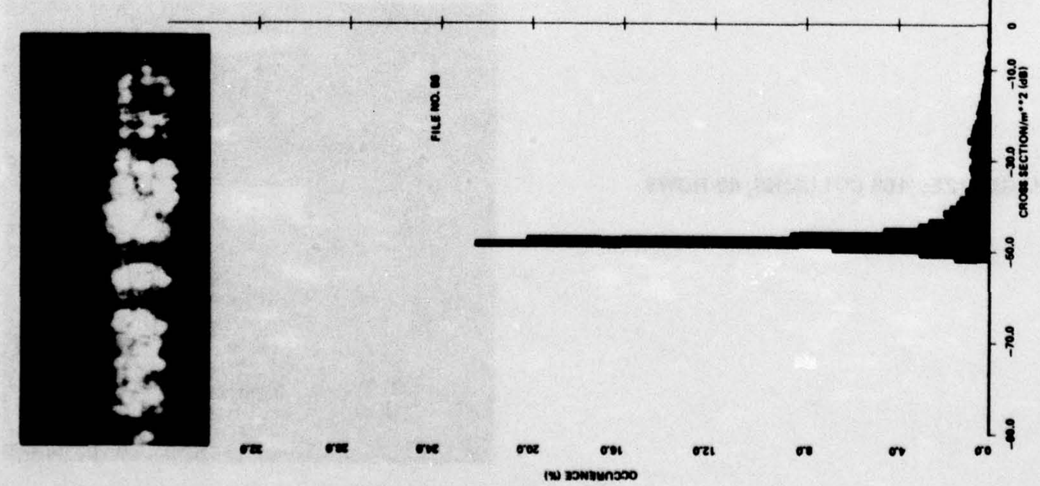
TARGET: SAME AS FILE NO. 28–9, BUT AZ AND EL STEPS WERE 1.7 mrad, GIVING A HIGHER DENSITY OF DATA POINTS.

IMAGE SIZE: 216 COLUMNS, 90 ROWS

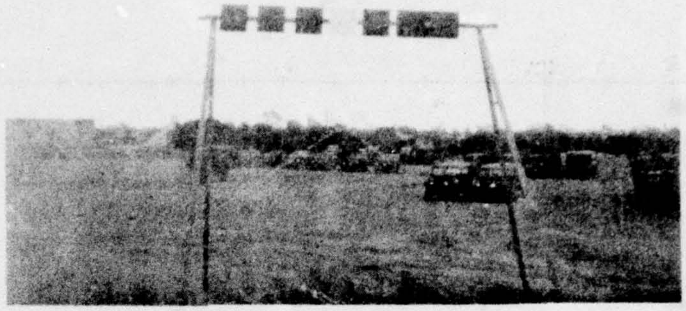
FILE NO.	V_s	WAVELENGTH
56	3.6	3.2 mm
57	7.1	10.6 μm
58	–	VISIBLE

NOTE: A LIGHT RAIN WAS FALLING.


FILE NO. 57
CROSS SECTION/m**2 (dB)
OCCURENCE (%)


FILE NO.
CROSS SECTION/m**2 (dB)
OCCURENCE (%)

SCAN NO. 28–9

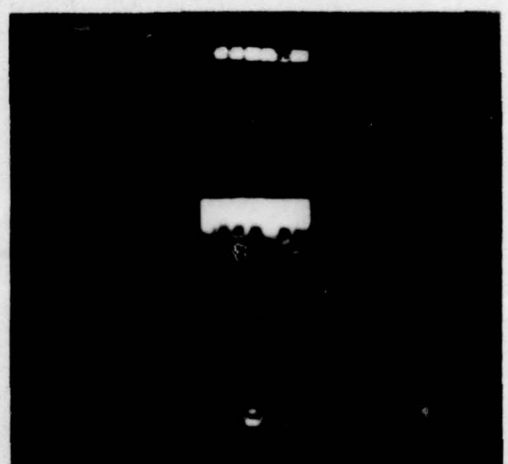


TARGETS: PAINTED ALUMINUM PANELS 1 1/2 ft SQUARE. THE PRIMER WAS 1757–TT–P–1757 ZINC CHROMATE PRIMER, GREEN NO. 34151. THE TOP COATS WERE FROM LEFT TO RIGHT.

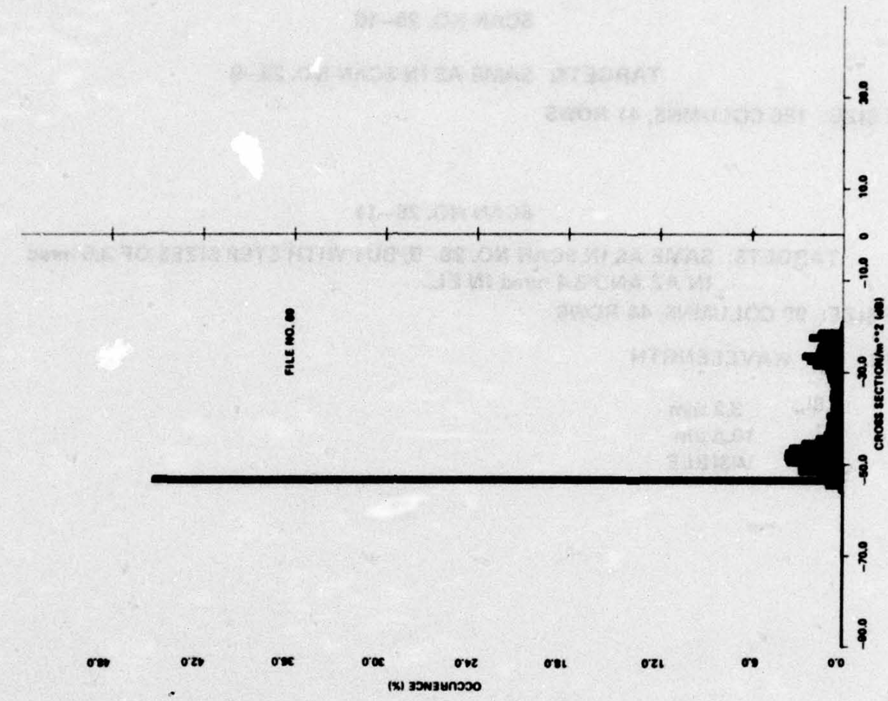
1. MIL–E–52798 LUSTERLESS ENAMEL, CAMOUFLAGE. FOREST GREEN (USED ON NEW PERSHING, LANCE, AND TOW).
2. MIL–E–52227 SEMIGLOSS ENAMEL NO. 24037,

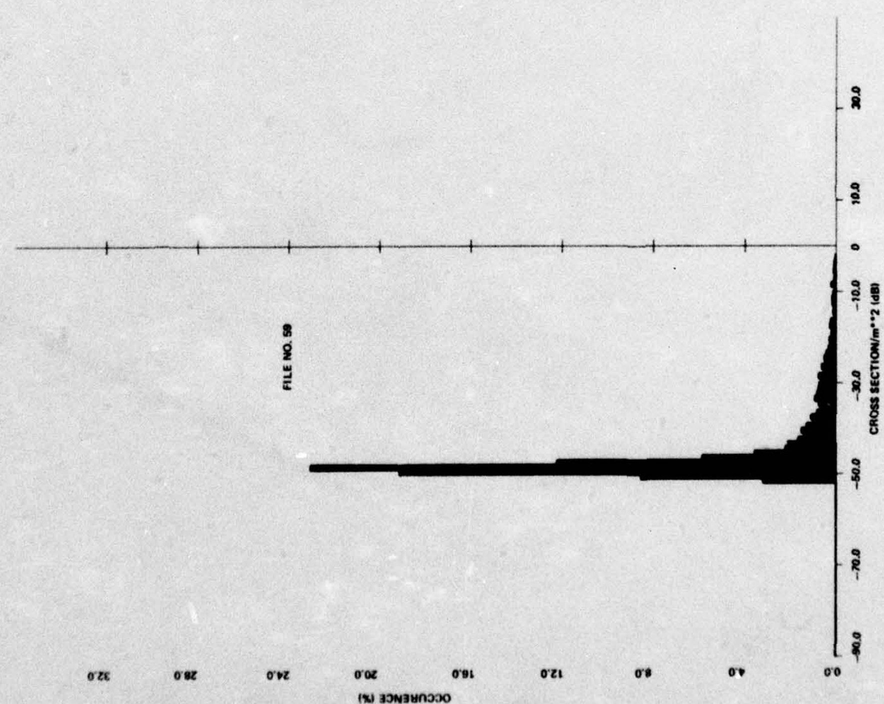
1. MIL–E–52798 LUSTERLESS ENAMEL, CAMOUFLAGE. FOREST GREEN (USED ON NEW PERSHING, LANCE, AND TOW).
2. MIL–E–52227 SEMIGLOSS ENAMEL, OLIVE DRAB NO. 24037, (USED ON LANCE).
3. TT–E–527 LUSTERLESS ENAMEL, OLIVE DRAB NO. 34087 (USED ON PERSHING).
4. TT–E–516 LUSTERLESS ENAMEL, WHITE NO. 37875.
5. TT–E–489 GLOSS ENAMEL, BLACK NO. 17038.
6. MIL–E–46136 SEMIGLOSS SOLAR HEAT REFLECTING ENAMEL, TYPE II, OLIVE DRAB NO. 24087, WITH A MIL–E–46127 GRAY SOLAR HEAT REFLECTING UNDERCOAT.
7. MIL–E–46096 LUSTERLESS SOLAR HEAT REFLECTING ENAMEL, OLIVE DRAB NO. 34087, WITH A TT–E–516 LUSTERLESS ENAMEL, WHITE UNDERCOAT (USED ON HERCULES AND HAWK).

IMAGE SIZE: 168 COLUMNS, 43 ROWS



NOTE: THE 3.2 mm HETERODYNE LOST LOCK SO THE RUN WAS REPEATED IN SCAN NO. 28–10. RAIN WAS FALLING AND SCAN NO. 28–10 HAD TO BE TERMINATED BEFORE A CALIBRATION CHECK COULD BE OBTAINED. WHEN THE EQUIPMENT WAS TURNED ON AGAIN AFTER THE RAIN, THE CALIBRATION VOLTAGES WERE THE SAME AS IN SCAN NO. 28–8.


FILE NO. 58
CROSS SECTION/m**2 (dB)
OCCURENCE (%)
-90.0
-70.0
-50.0
-30.0
-10.0
0
10.0
20.0
0.0
6.0
12.0
18.0
24.0
30.0
36.0
42.0
48.0


FILE NO. 59
CROSS SECTION/m**2 (dB)
OCCURENCE (%)
-90.0
-70.0
-50.0
-30.0
-10.0
0
10.0
20.0
0.0
4.0
8.0
12.0
16.0
20.0
24.0
28.0
32.0

SCAN NO. 28–10

TARGETS: SAME AS IN SCAN NO. 28–9

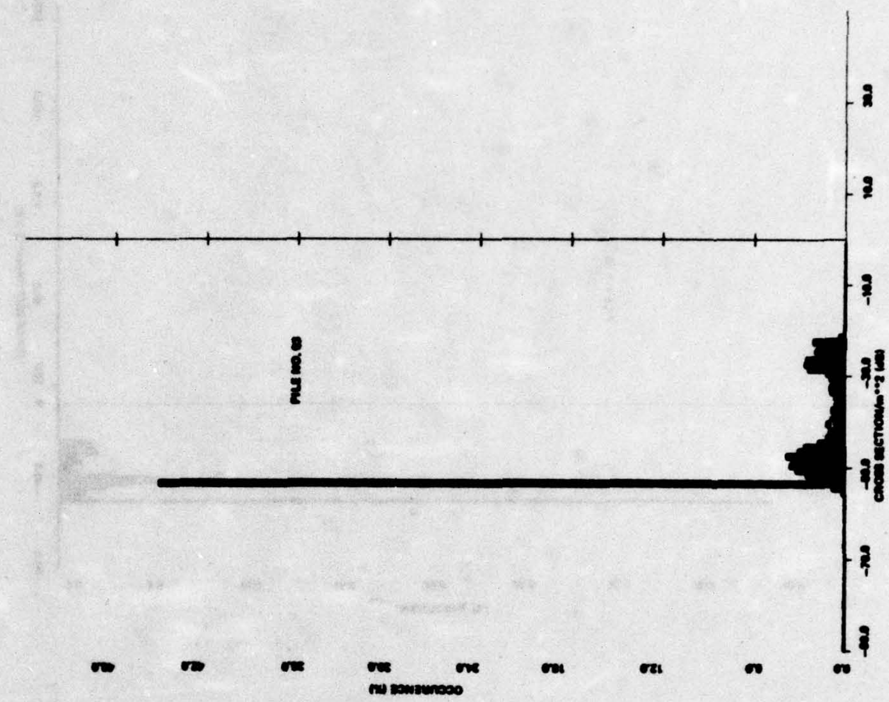
IMAGE SIZE: 186 COLUMNS, 41 ROWS

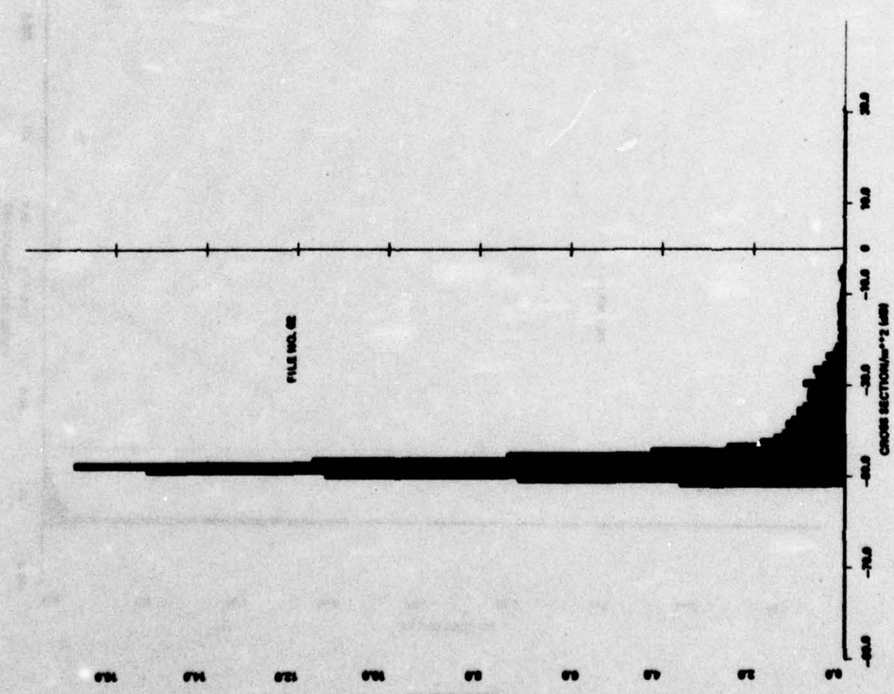
SCAN NO. 28–11

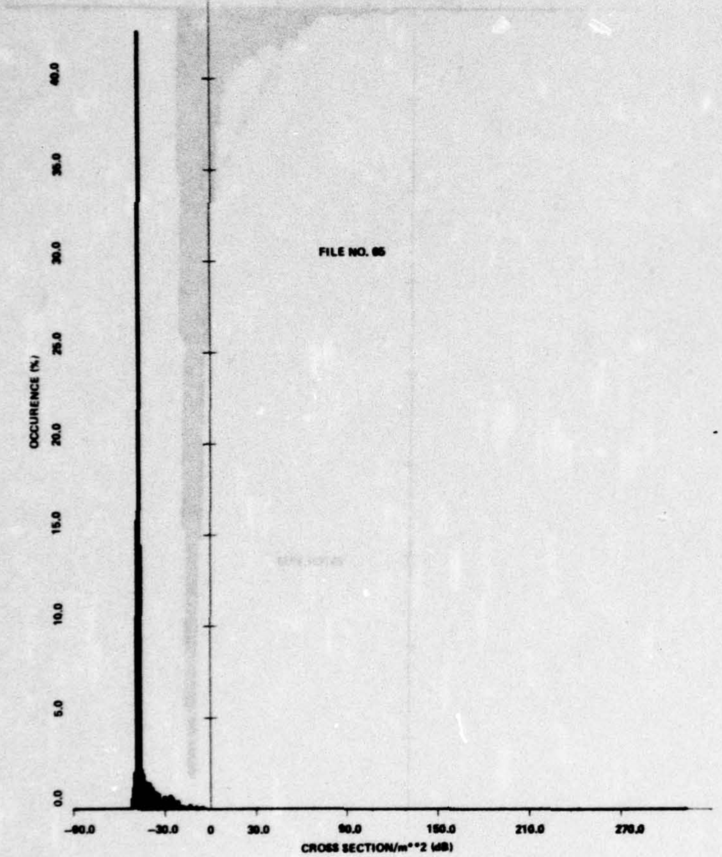
TARGETS: SAME AS IN SCAN NO. 28–9, BUT WITH STEP SIZES OF 3.5 mrad IN AZ AND 3.4 mrad IN EL.

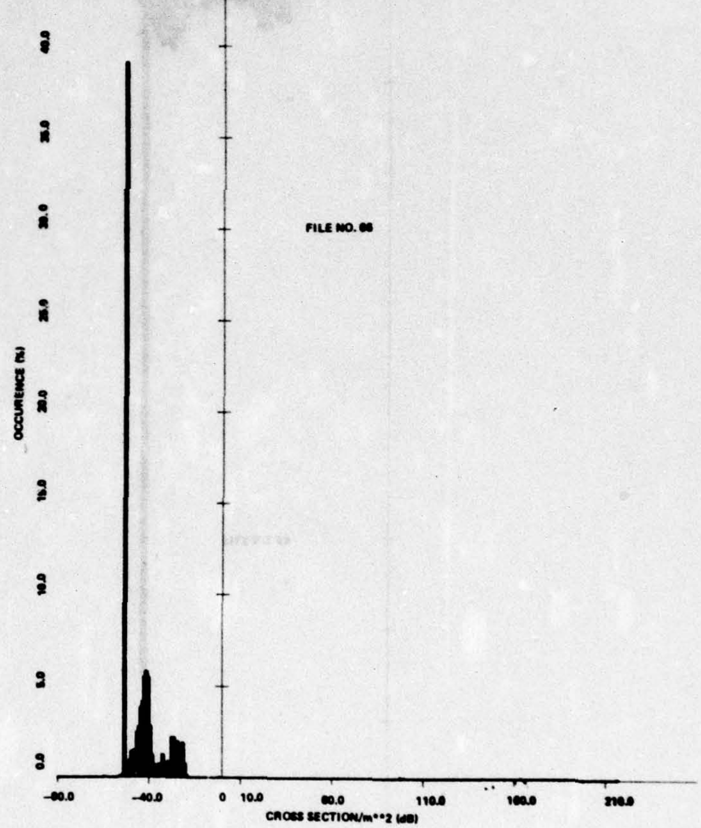
IMAGE SIZE: 99 COLUMNS, 44 ROWS

FILE NO.	V_s	WAVELENGTH
65	3.8	3.2 mm
66	7.1	10.6 μm
67	–	VISIBLE

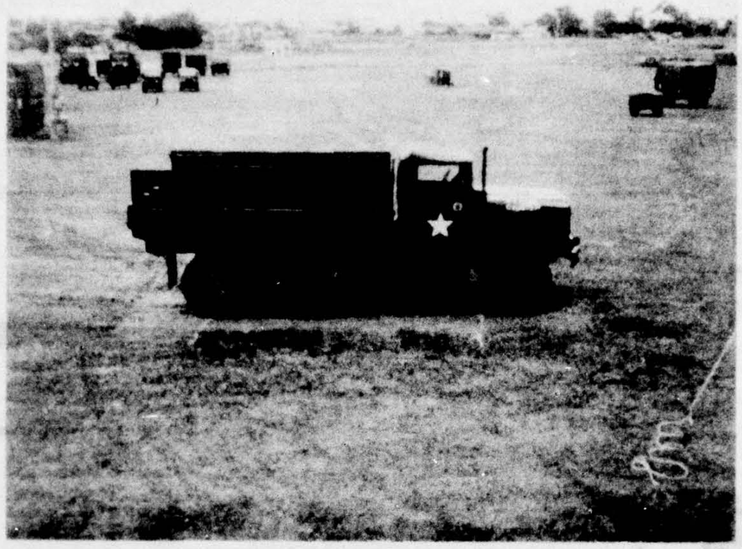





FILE NO. 65
OCCURENCE (%)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
-90.0
-30.0
0
30.0
90.0
150.0
210.0
270.0
CROSS SECTION/m**2 (dB)


FILE NO. 66
OCCURENCE (%)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
-80.0
-40.0
0
10.0
80.0
110.0
160.0
210.0
CROSS SECTION/m**2 (dB)

SCAN NO. 28–12

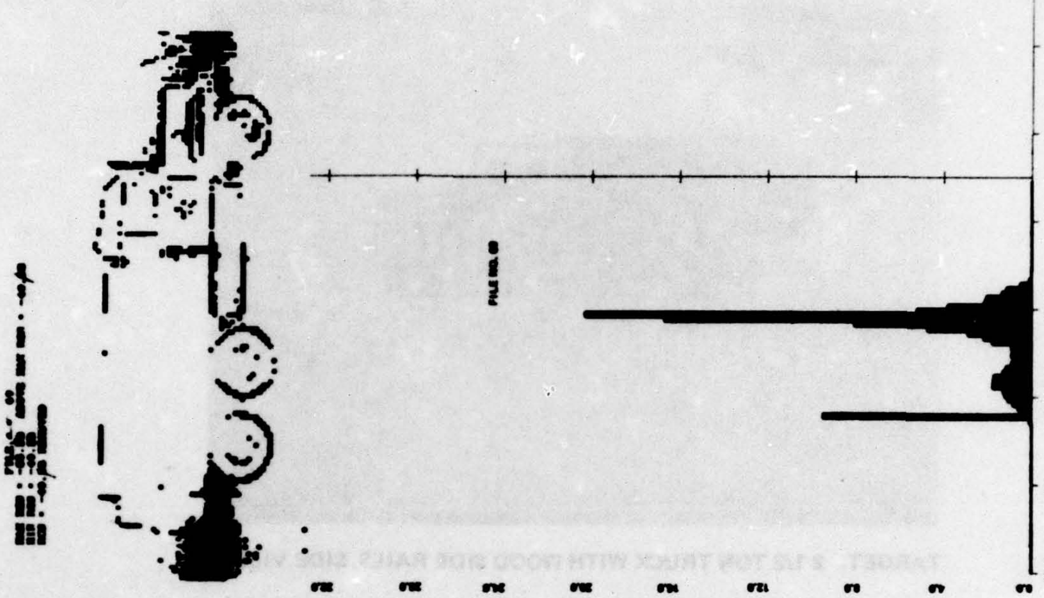


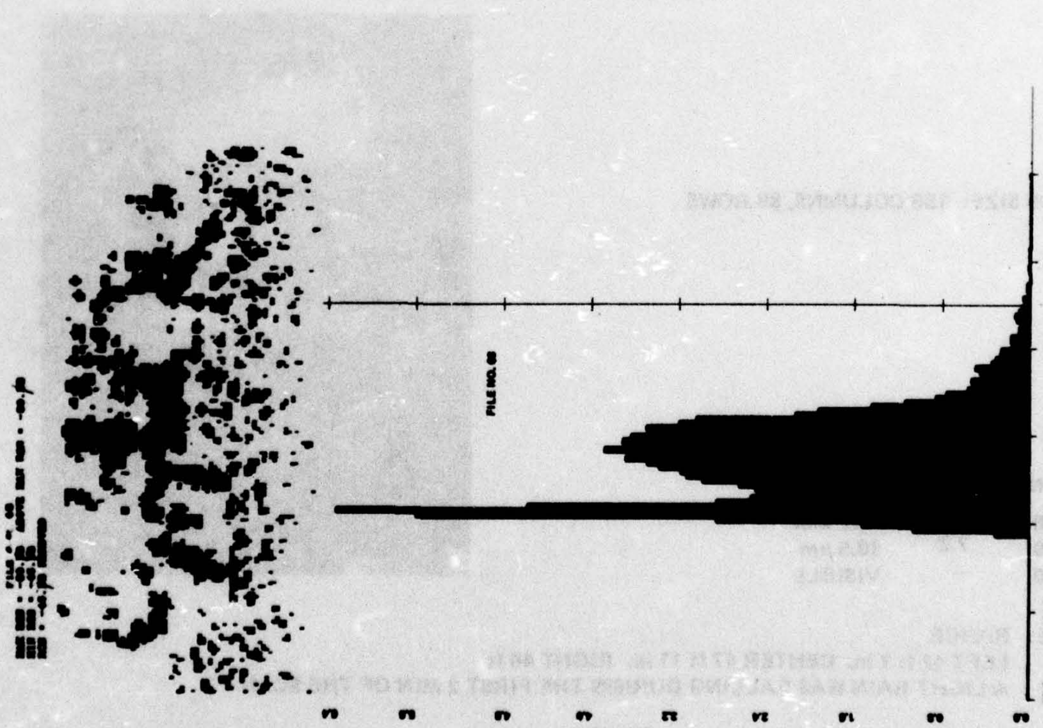
TARGET: 2 1/2 TON TRUCK WITH WOOD SIDE RAILS, SIDE VIEW.

IMAGE SIZE: 156 COLUMNS, 88 ROWS

FILE NO.	V_s	WAVELENGTH
68	3.7	3.2 mm
69	7.2	10.6 μm
70	–	VISIBLE

NOTE: RANGE
LEFT 47 ft 1 in. CENTER 47 ft 11 in. RIGHT 46 ft
A LIGHT RAIN WAS FALLING DURING THE FIRST 2 MIN OF THE SCAN.





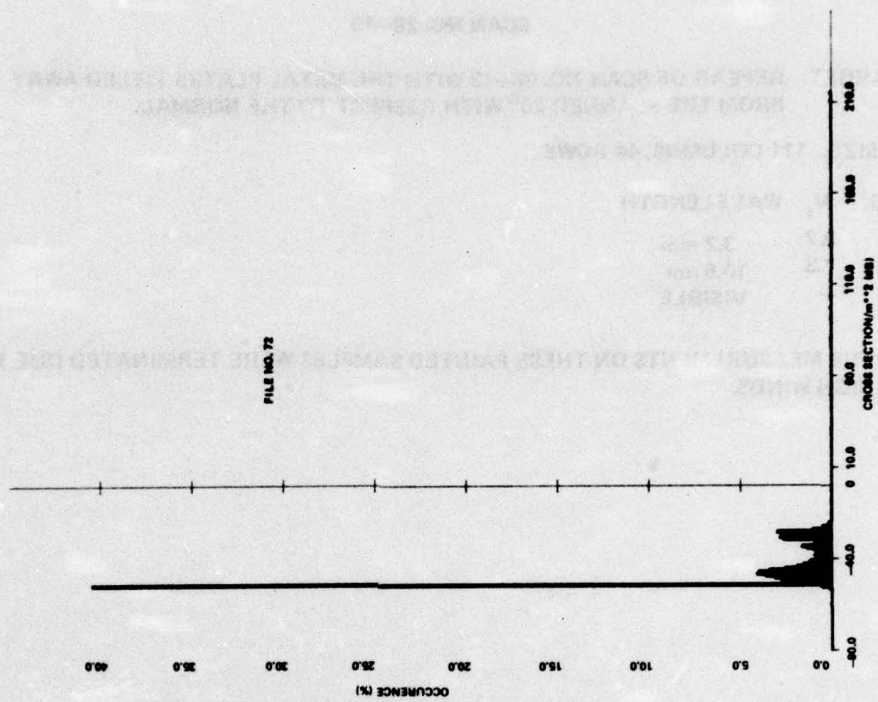
SCAN NO. 28–13

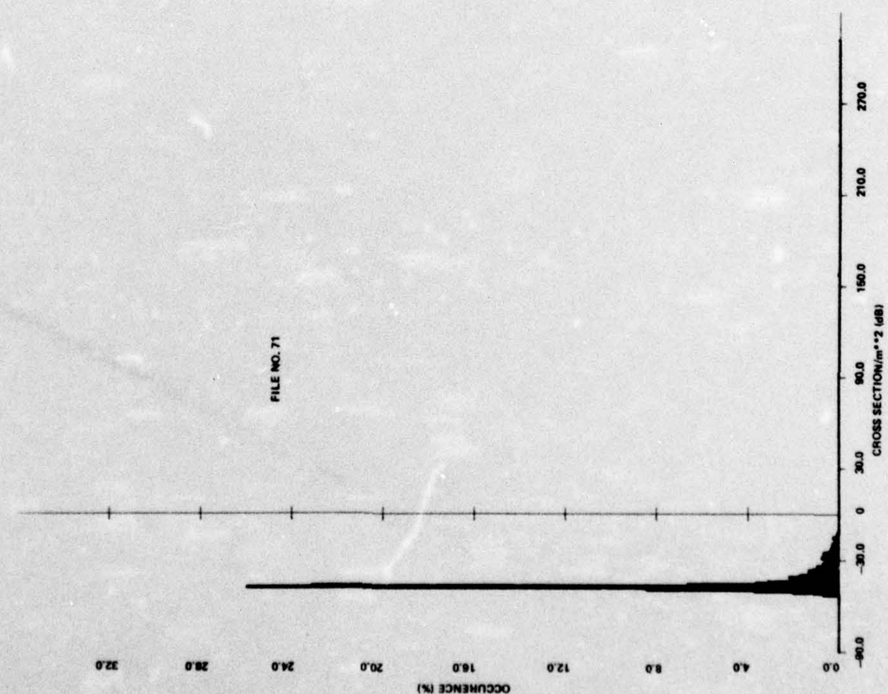
TARGET: REPEAR OF SCAN NO. 28–13 WITH THE METAL PLATES TITLED AWAY FROM THE SCANNER 20° WITH RESPECT TO THE NORMAL.

IMAGE SIZE: 111 COLUMNS, 44 ROWS

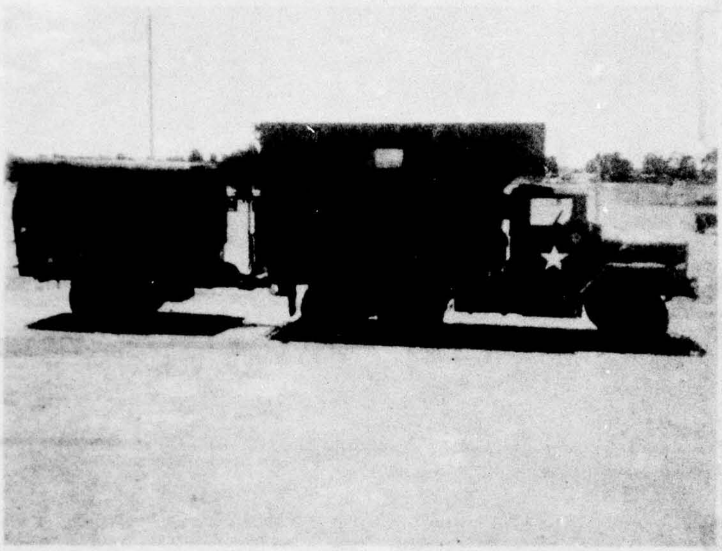
FILE NO.	V_s	WAVELENGTH
71	3.7	3.2 mm
72	7.3	10.6 μm
73	–	VISIBLE

NOTE: THE MEASUREMENTS ON THESE PAINTED SAMPLES WERE TERMINATED DUE TO HIGH WINDS.


FILE NO. 72
CROSS SECTION/m**2 (dB)
OCCURENCE (%)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0


FILE NO. 71
CROSS SECTION/m**2 (dB)
OCCURENCE (%)
-80.0
-30.0
0
30.0
90.0
150.0
210.0
270.0
0.0
4.0
8.0
12.0
16.0
20.0
24.0
28.0
32.0

SCAN NO. 28–14



TARGET: SIZE VIEW OF MOBILE FIELD KITCHEN, CONSTRUCTED OF PLYWOOD ON A 2 1/2 TON TRUCK BEN. SUPPLY TRAILER IS ATTACHED TO TRUCK.

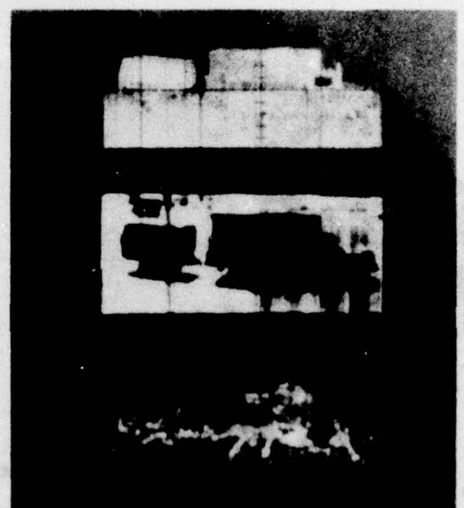
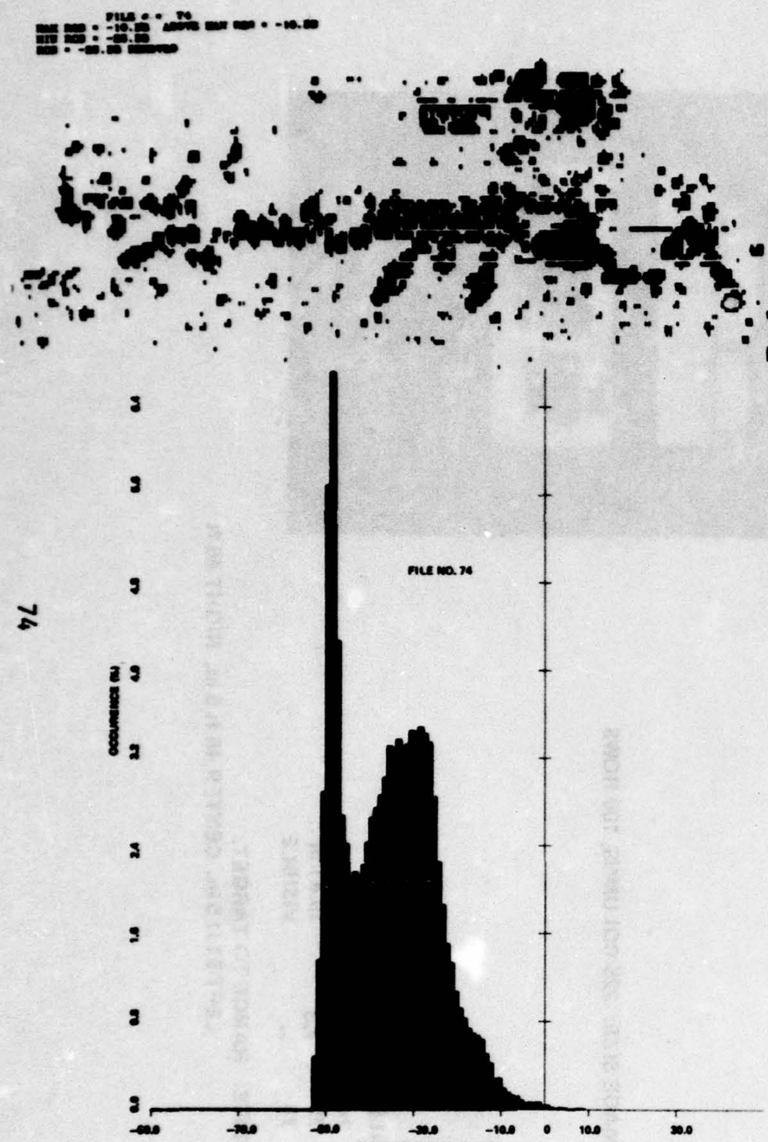
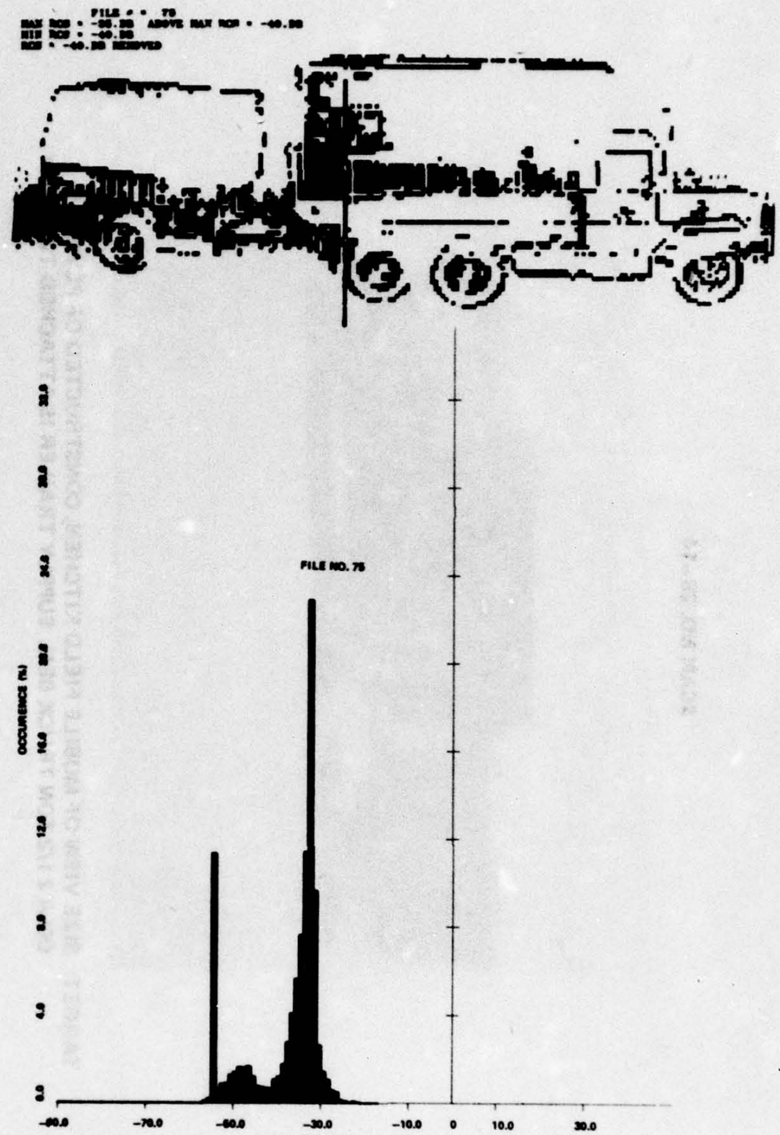


IMAGE SIZE: 225 COLUMNS, 100 ROWS

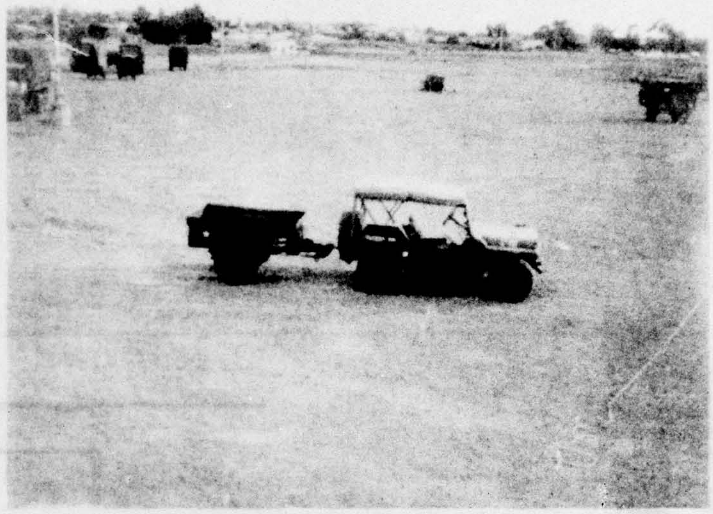
FILE NO.	V_s	WAVELENGTH
74	3.7	3.2 mm
75	7.3	10.6 μm
76	–	VISIBLE

NOTE: RANGE TO TARGET.
LEFT 51 ft 5 in. CENTER 46 ft 5 in. RIGHT 46 ft


FILE NO. 74
OCCURENCE (%)
CROSS SECTION/m**2 (dB)


FILE NO. 75
OCCURENCE (%)
CROSS SECTION/m**2 (dB)

SCAN NO. 29–1



TARGET: SIDE VIEW OF JEEP WITH TRAILER.

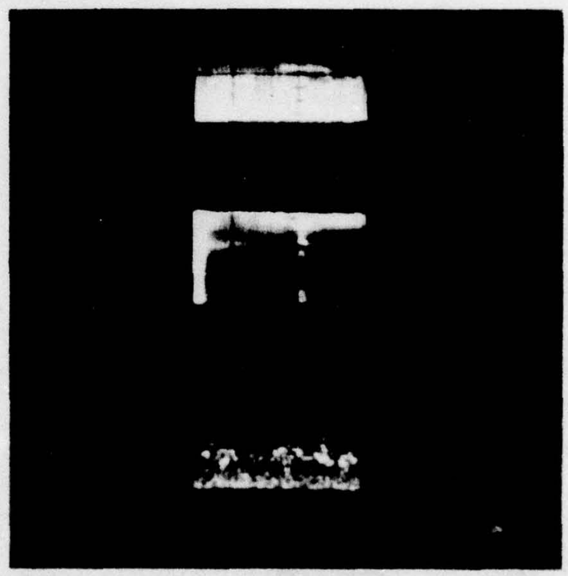


IMAGE SIZE: 123 COLUMNS, 69 ROWS

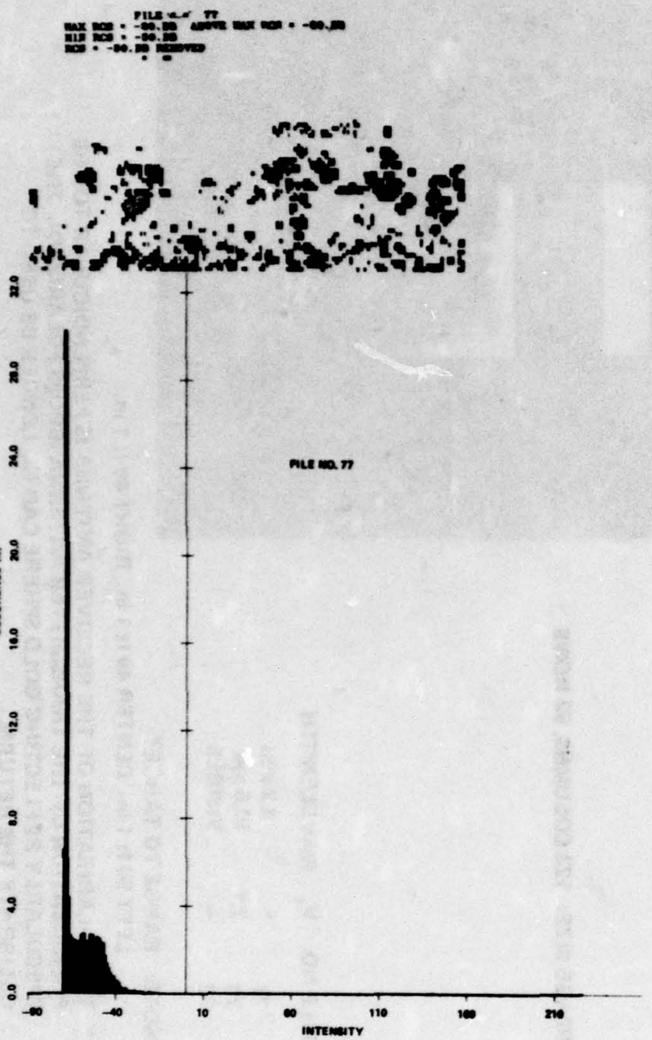
FILE NO.	V_s	WAVELENGTH
77	*	3.2 mm
78	7.1	10.6 μm
79	–	VISIBLE

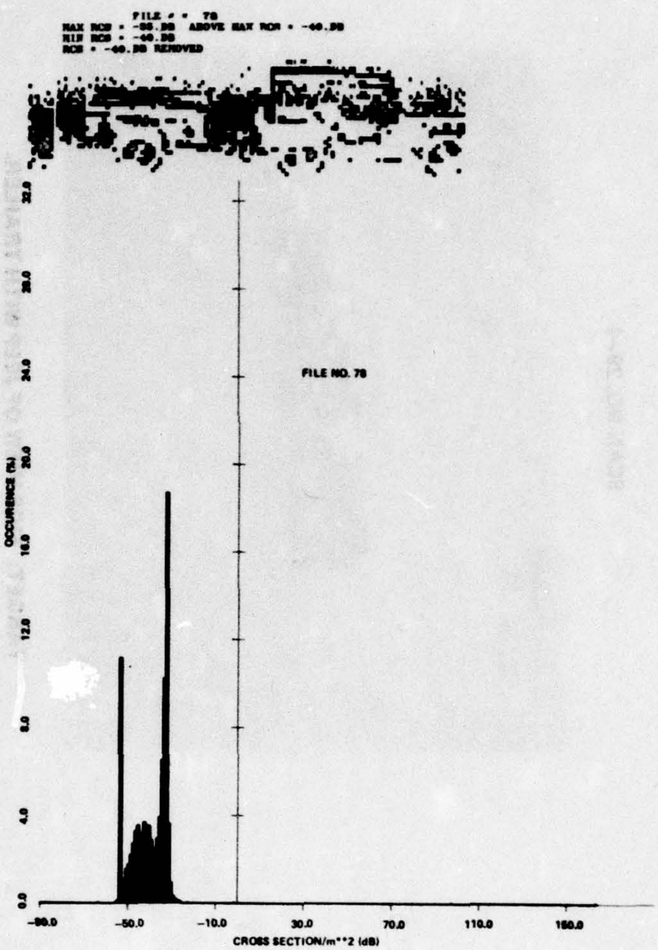
NOTE: RANGE TO TARGET.
LEFT 50 ft 1 in. CENTER 49 ft 1 in. RIGHT 49 ft 1 in.

* THE POLARIZATION OF THE RECEIVER ANTENNA IS PERPENDICULAR TO THE POLARIZATION OF THE TRANSMITTER ANTENNA (CROSS POLARIZED). THE SPECULARLY REFLECTING GOLD SPHERE CAN NO LONGER BE USED TO CALIBRATE THE RETURN.

IN ALL PREVIOUS SCANS, 10 dB OF ATTENUATION WAS PLACED AT THE RECEIVER ANTENNA; IN ALL OF THE REMAINING SCANS, NO ATTENUATION WAS USED IN THE RECEIVER.

IN ALL OF THE CROSS POLARIZED SCANS THE 10.6 μm SCANS WERE NOT MODIFIED; THUS, THEY CONTAIN NO NEW INFORMATION.


FILE NO. 77
OCCURENCE (%)
0.0
4.0
8.0
12.0
16.0
20.0
24.0
28.0
32.0
-90
-40
10
60
110
160
210
INTENSITY


RCS = -40.DB REMOVED
FILE NO. 78
OCCURENCE (%)
0.0
4.0
8.0
12.0
16.0
20.0
24.0
28.0
32.0
-90.0
-50.0
-10.0
30.0
70.0
110.0
150.0
CROSS SECTION/m**2 (dB)

SCAN NO. 29–2

TARGET: M48 TANK, VIEW IS HEAD–ON

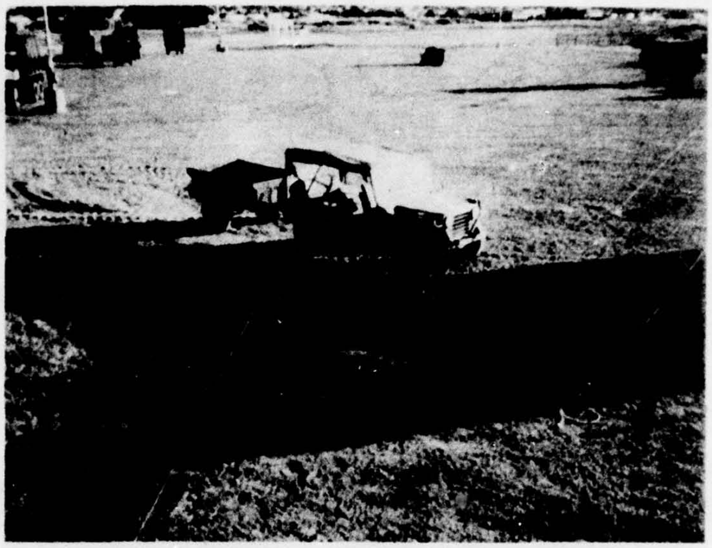
IMAGE SIZE: 99 COLUMNS, 103 ROWS

FILES NO. 80 (3.2 mm) AND 82 (VISIBLE) ARE UNCALIBRATED.
FILE NO. 81 (10.6 μm) HAS A V_s = 7.1.

NOTE: RANGE TO TARGET.
LEFT 44 ft 7 in. CENTER 45 ft RIGHT 46 ft 4 in.

THE 3.2 mm DATA ARE CROSS POLARIZED.

SCAN NO. 29–3



TARGET: JEEP WITH RUBBERIZED CANVAS TOP AND TRAILER – 45° VIEW

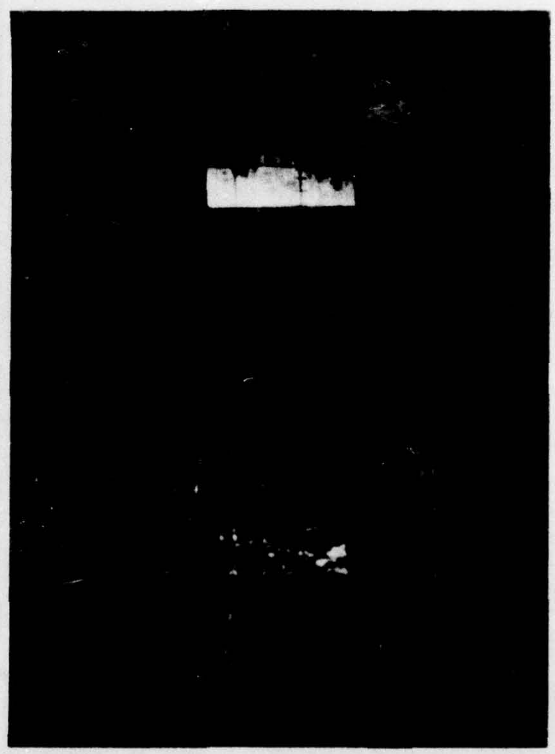
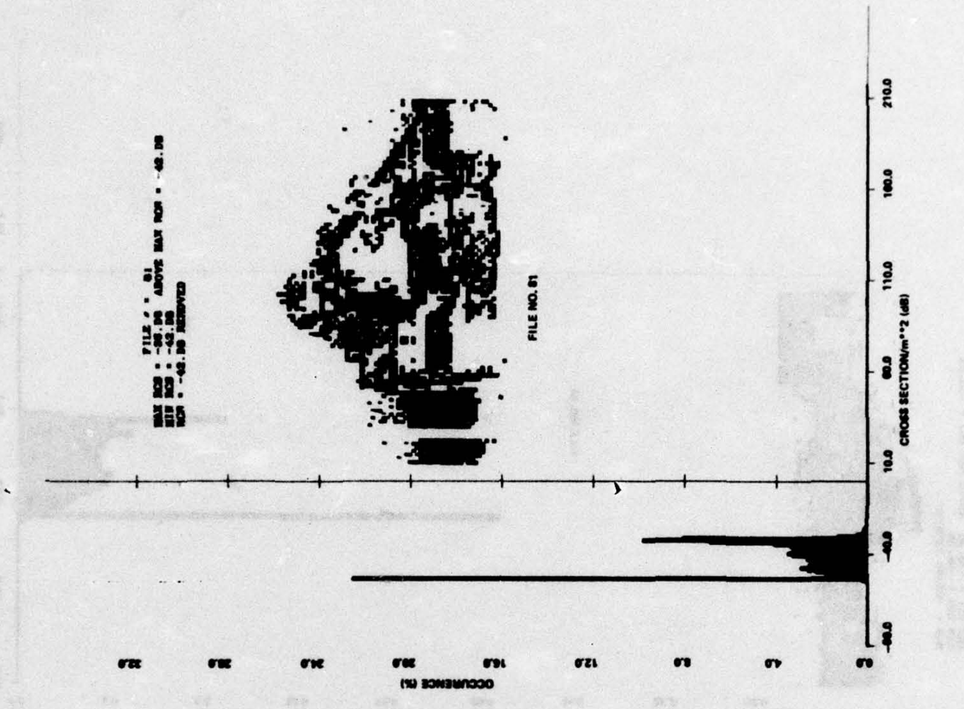
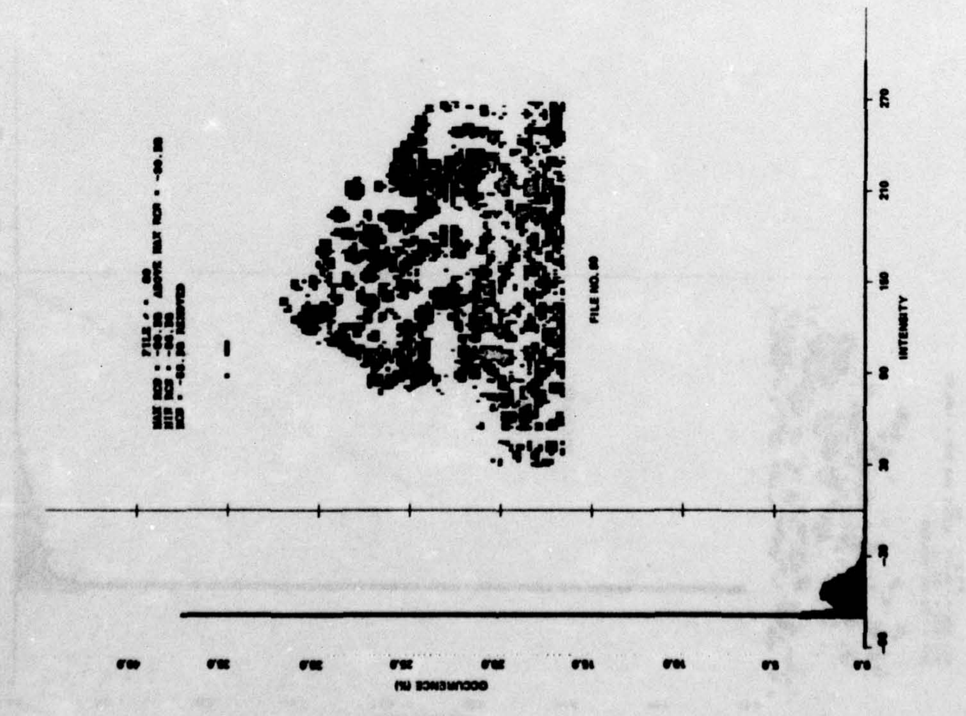


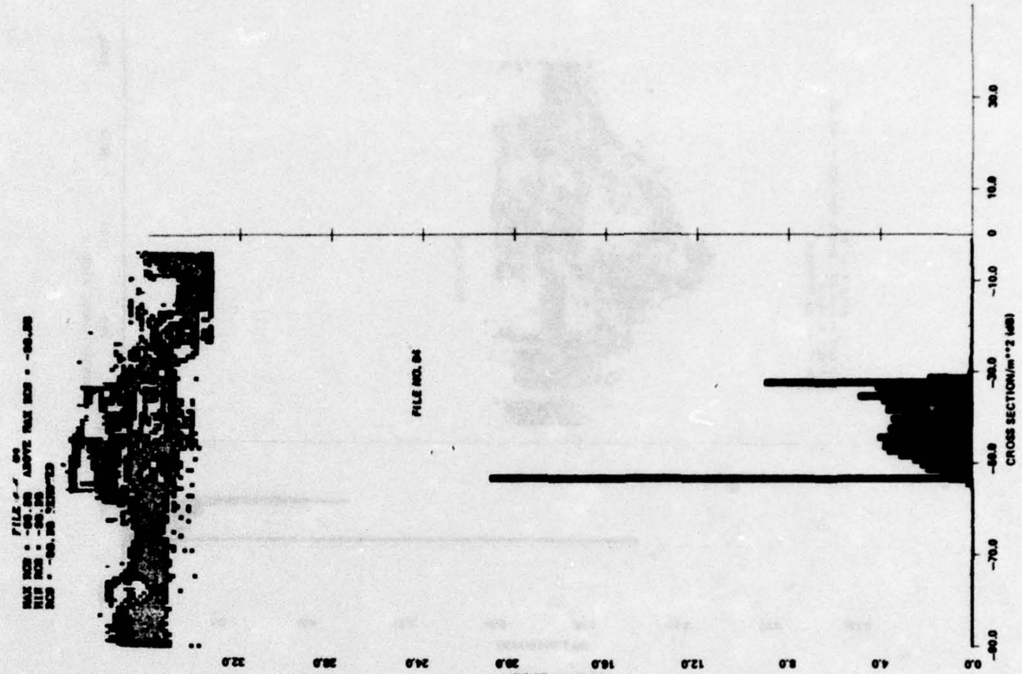
IMAGE SIZE: 108 COLUMNS, 79 ROWS

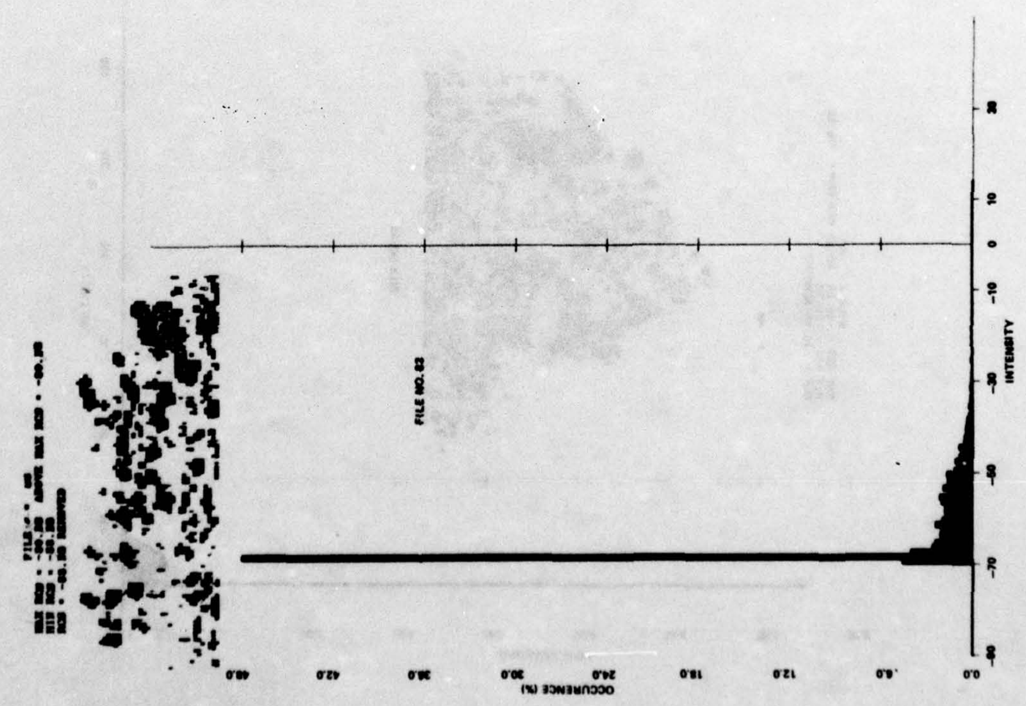
FILE NO.	WAVELENGTH	
83	3.2 mm	
84	10.6 μm	CROSS POLARIZED
85	VISIBLE	

RANGE TO TARGET
LEFT 57 ft [illegible] in. CENTER 48 ft 11 in. RIGHT 50 ft 3 in.


FILE NO. 01
CROSS SECTION/m**2 (dB)
OCCURENCE (%)


FILE NO. 00
INTENSITY
OCCURENCE (%)


FILE NO. 84
OCCURENCE (%)
CROSS SECTION/m**2 (dB)


FILE NO. 83
OCCURENCE (%)
INTENSITY

SCAN NO. 29–4

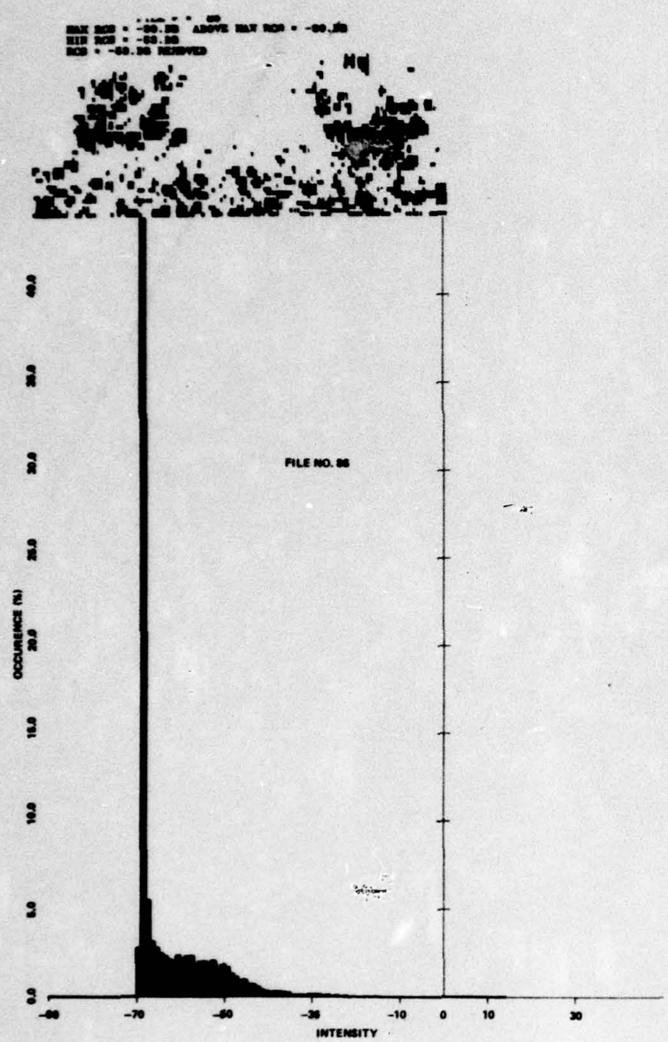
TARGET: 2 JEEPS, ONE REAR VIEW AND ONE FRONT VIEW

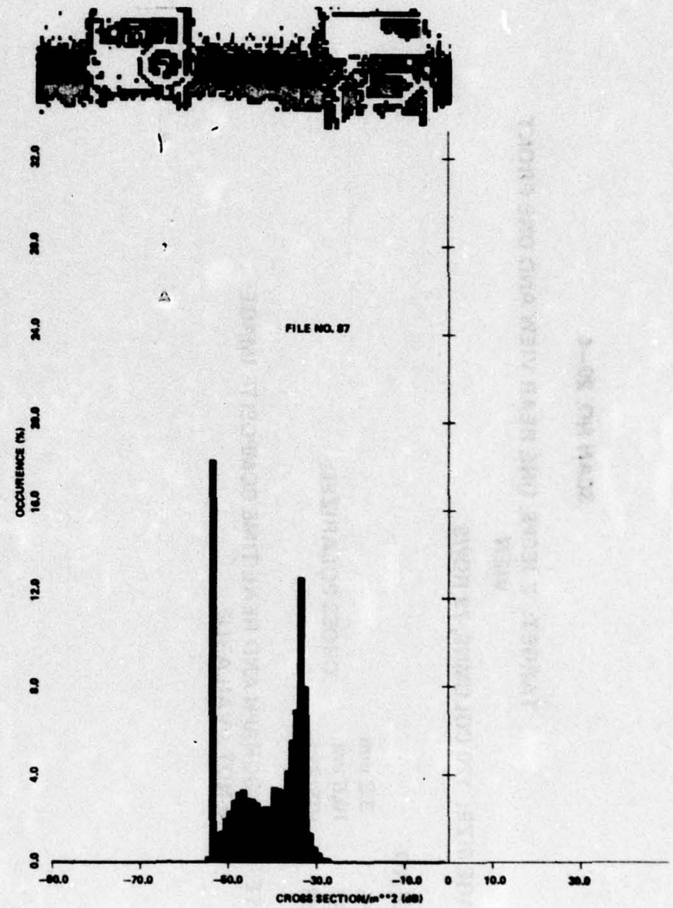
IMAGE SIZE: 120 COLUMNS, 78 ROWS

FILE NO.

86	3.2 mm	
87	10.6 μm	CROSS POLARIZED
88	VISIBLE	

NOTE: PHOTOGRAPH AND REAL TIME COMPOSITE IMAGE ARE NOT AVAILABLE


ABOVE MAX RCS
FILE NO. 86
OCCURENCE (%)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
INTENSITY
-80
-70
-50
-35
-10
0
10
30


FILE NO. 87
OCCURENCE (%)
0.0
4.0
8.0
12.0
16.0
20.0
24.0
28.0
32.0
CROSS SECTION/m**2 (dB)
-80.0
-70.0
-50.0
-30.0
-10.0
0
10.0
30.0

SCAN NO. 29–5

TARGET: 2 1/2 TON CANVAS COVERED TRUCK WITH WATER TANK TRAILER – SIDE VIEW

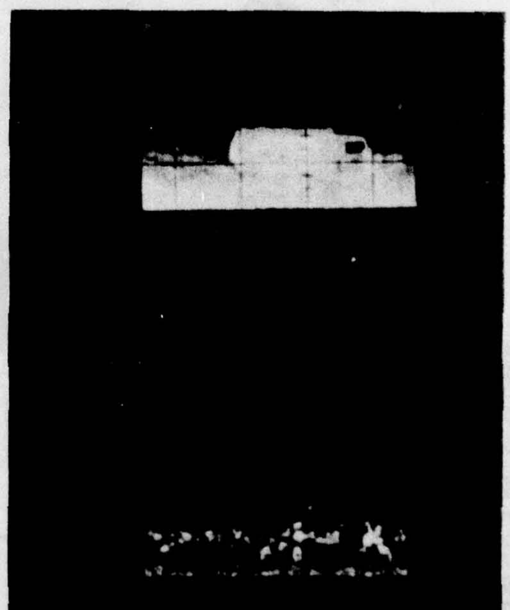
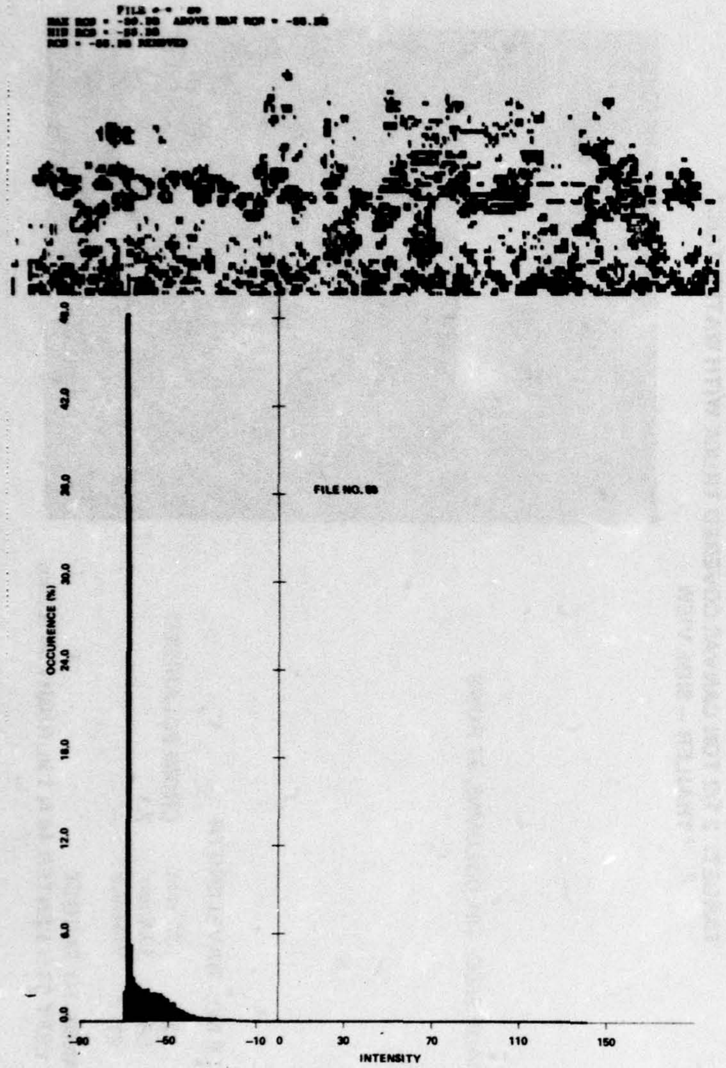


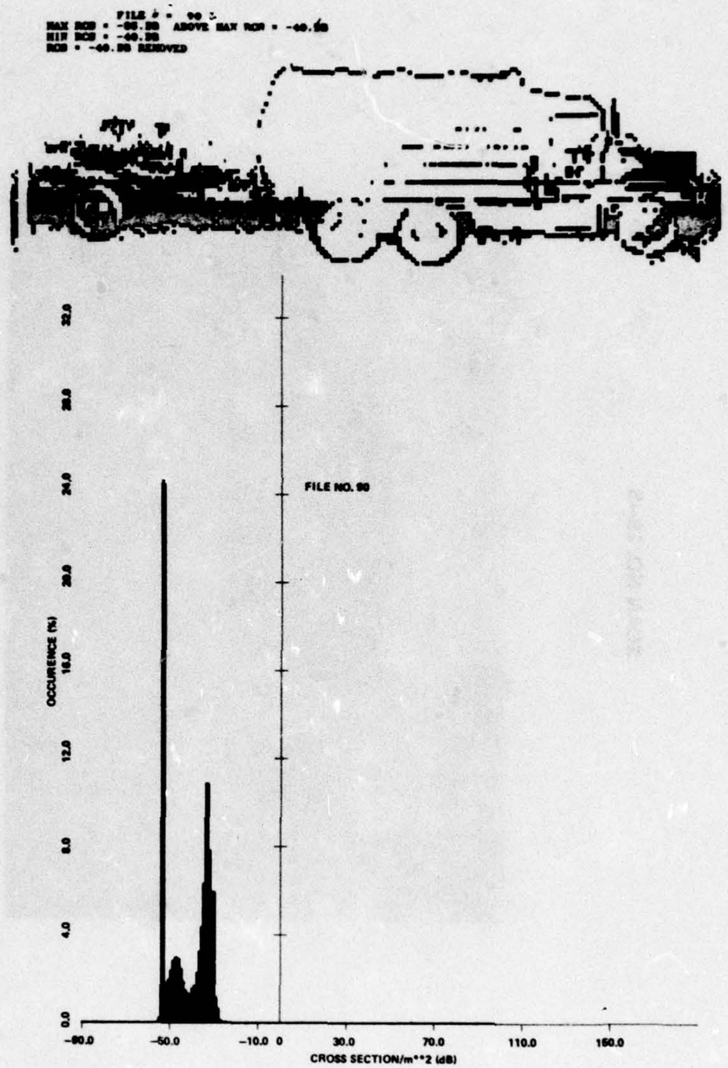
IMAGE SIZE: 201 COLUMNS, 97 ROWS

FILE NO.	WAVELENGTH	V_s
89	3.2 mm	CROSS POLARIZED
90	10.6 μm	7.1
91	VISIBLE	–

RANGE TO TARGET
LEFT 53 ft CENTER 48 ft 1 in. RIGHT 50 ft 2 in.

NOTE: SCAN MADE AT DUSK SO THERE IS NO VISIBLE IMAGE


FILE NO. 89
OCCURENCE (%)
0.0
6.0
12.0
18.0
24.0
30.0
36.0
42.0
48.0
-90
-50
-10
0
30
70
110
150
INTENSITY


FILE NO. 90
OCCURENCE (%)
0.0
4.0
8.0
12.0
16.0
20.0
24.0
28.0
32.0
-90.0
-50.0
-10.0
0
30.0
70.0
110.0
150.0
CROSS SECTION/m**2 (dB)

SCAN NO. 29–6

TARGET: 2 1/2 TON TRUCK WITH FLAT BED AND WOODEN SIDE RAILS – SIDE VIEW.

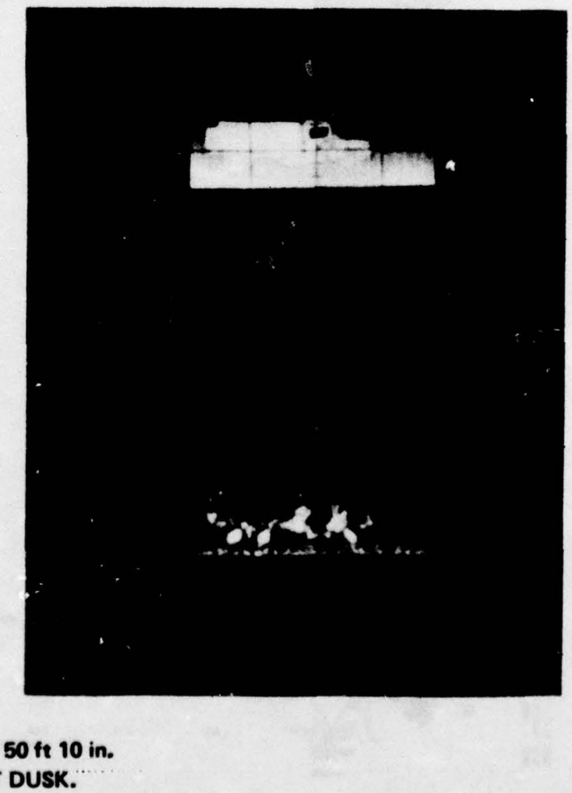


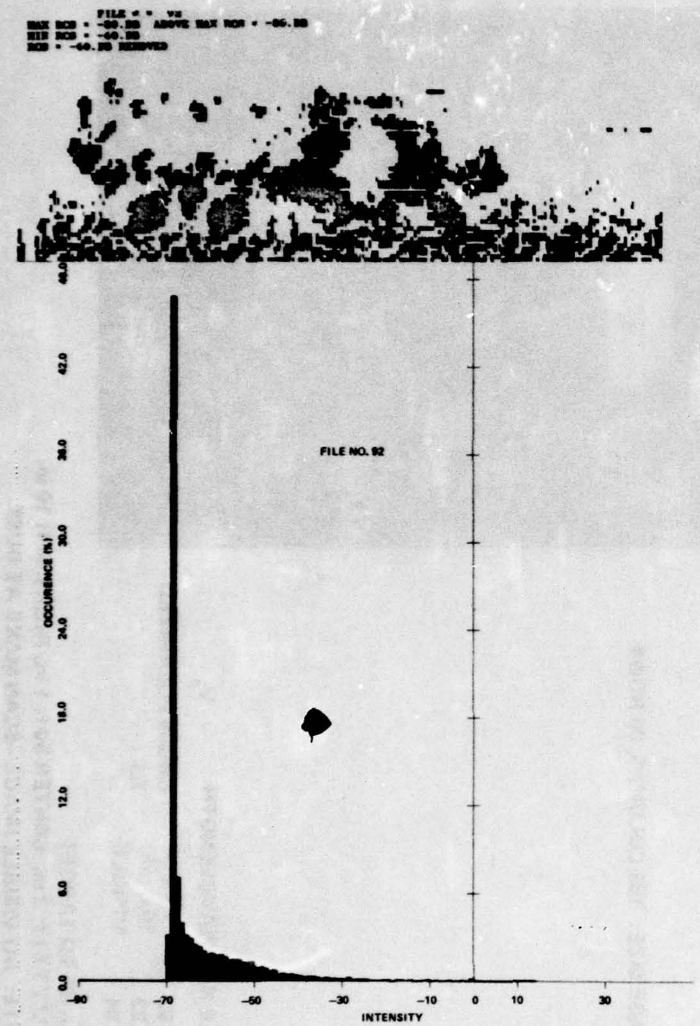
IMAGE SIZE: 183 COLUMNS, 96 ROWS

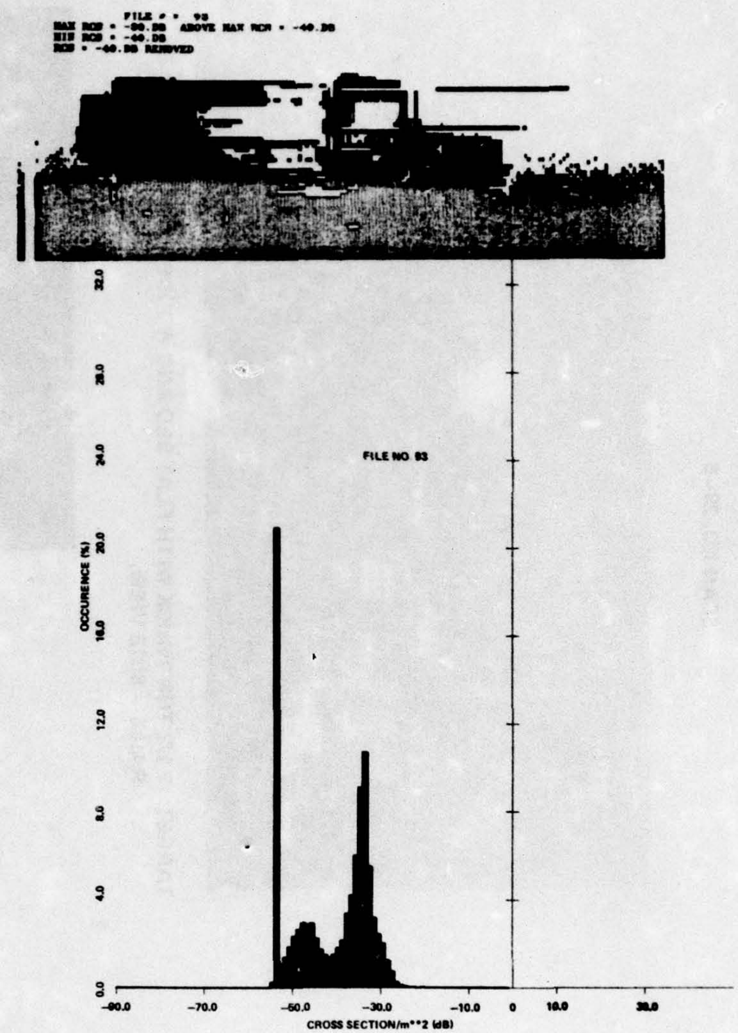
FILE NO.	WAVELENGTH	V_s
92	3.2 mm	CROSS POLARIZED
93	10.6 μm	7.1
94	VISIBLE	–

RANGE TO TARGET

LEFT 51 ft 2 in. CENTER 50 ft 1 in. RIGHT 50 ft 10 in.

NOTE: NO VISIBLE IMAGE–SCAN MAKE AT DUSK.

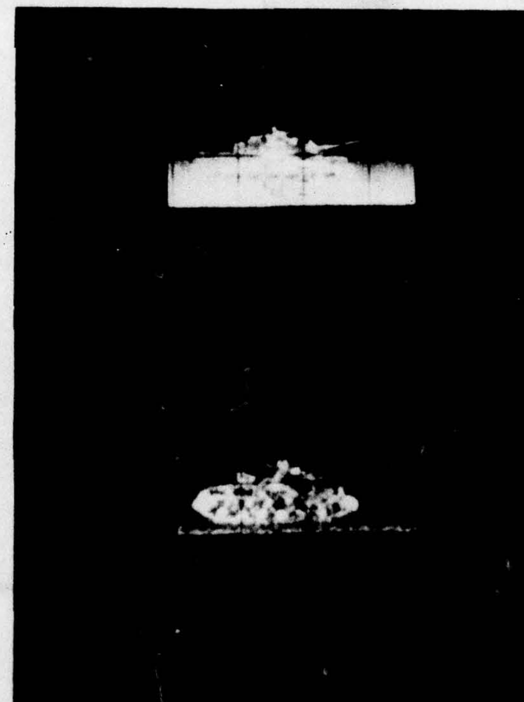

FILE NO. 92
OCCURENCE (%)
INTENSITY
0.0
6.0
12.0
18.0
24.0
30.0
36.0
42.0
48.0
-90
-70
-50
-30
-10
0
10
30


FILE NO 93
OCCURENCE (%)
CROSS SECTION/m**2 (dB)
0.0
4.0
8.0
12.0
16.0
20.0
24.0
28.0
32.0
-90.0
-70.0
-50.0
-30.0
-10.0
0
10.0
30.0

SCAN NO. 29–7

TARGET M48 TANK – SIDE VIEW

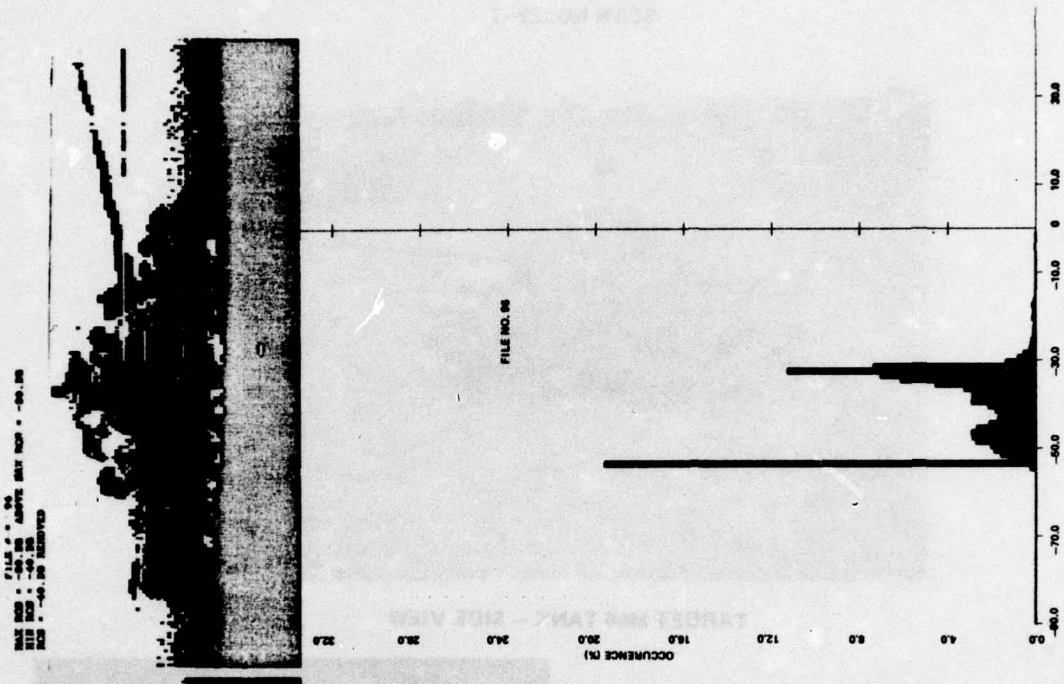
IMAGE SIZE: 183 COLUMNS, 89 ROWS

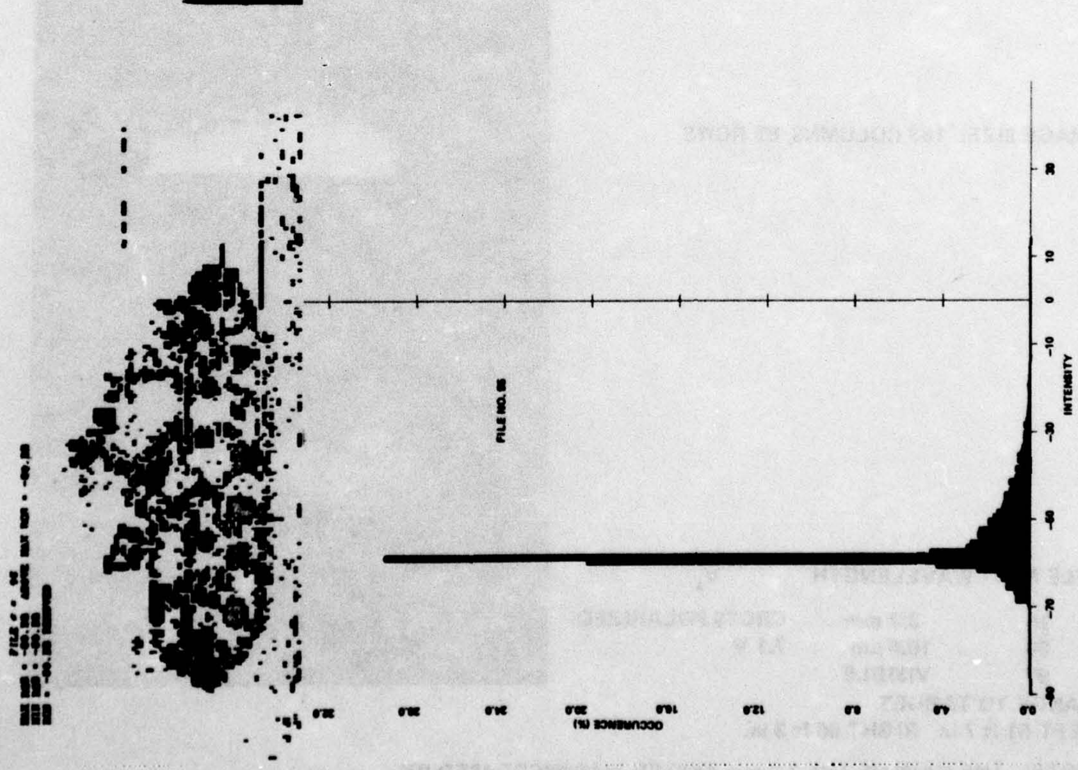


FILE NO.	WAVELENGTH	V_s
95	3.2 mm	CROSS POLARIZED
96	10.6 μm	7.1 V
97	VISIBLE	

RANGE TO TARGET
LEFT 51 ft 7 in. RIGHT 50 ft 3 in.

NOTE: THE GAIN OF THE 3.2 mm SYSTEM WAS INCREASED BY APPROXIMATELY A FACTOR OF FOUR. NO CHANGE WAS MADE IN THE 10.6 μm SYSTEM


FILE NO. 96
OCCURENCE (%)
CROSS SECTION/m**2 (dB)


FILE NO. 95
OCCURENCE (%)
INTENSITY

SCAN NO. 29–8

TARGET: M48 TANK AT 45 deg VIEW

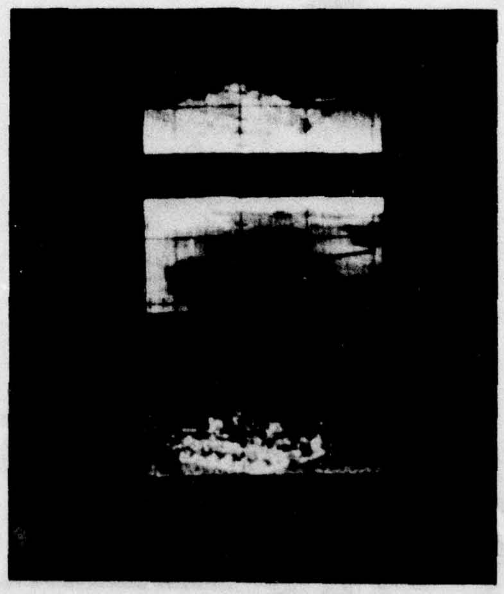
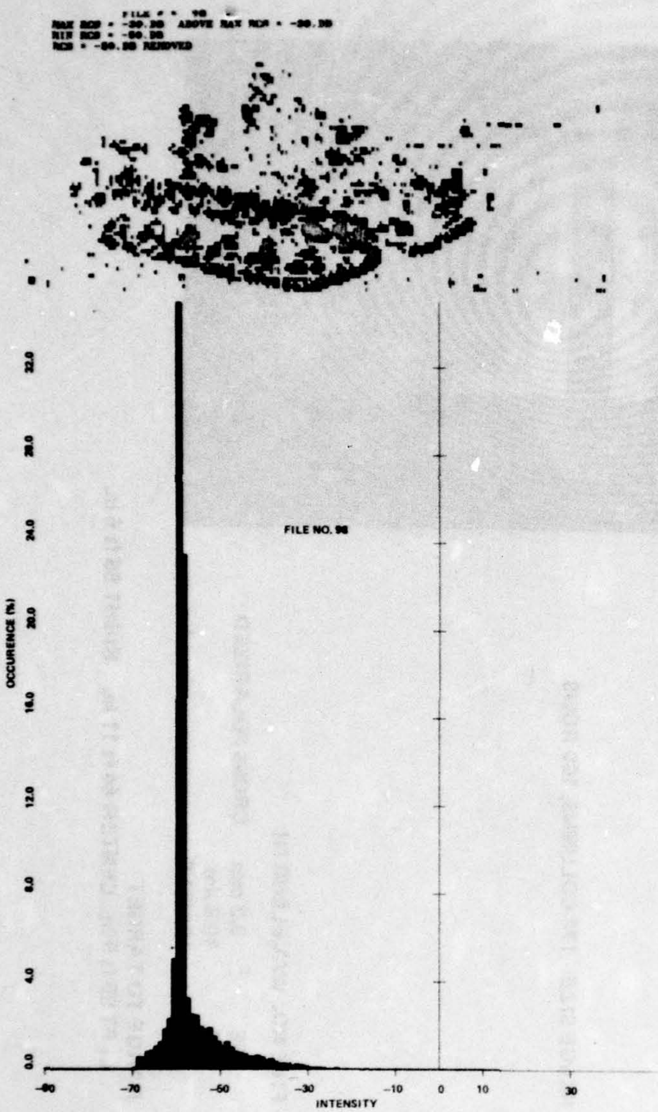
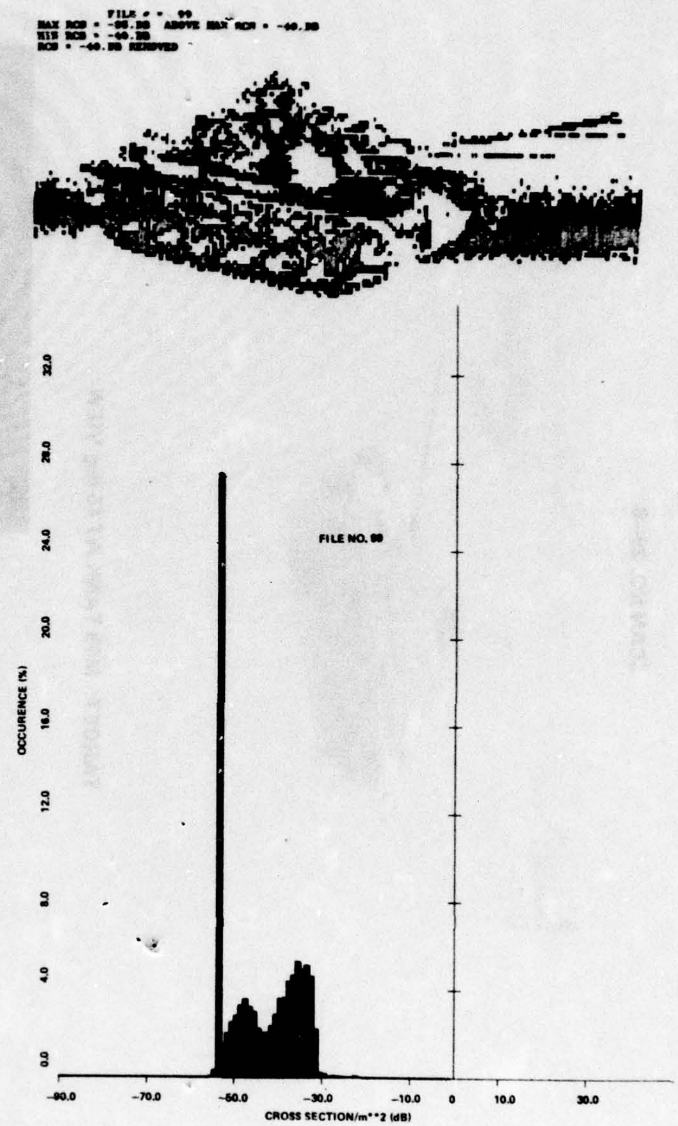


IMAGE SIZE: 174 COLUMNS, 100 ROWS

FILE NO.	WAVELENGTH	
98	3.2 mm	CROSS POLARIZED
99	10.6 μm	
100	VISIBLE	

RANGE TO TARGET
LEFT 59 ft 9 in. CENTER 44 ft 11 in. RIGHT 55 ft 5 in.


FILE NO. 98
OCCURENCE (%)
INTENSITY


FILE NO. 99
OCCURENCE (%)
CROSS SECTION/m**2 (dB)

SCAN NO. 29–9

TARGET: 2 1/2 TON CANVAS COVERED TRUCK – HEAD ON

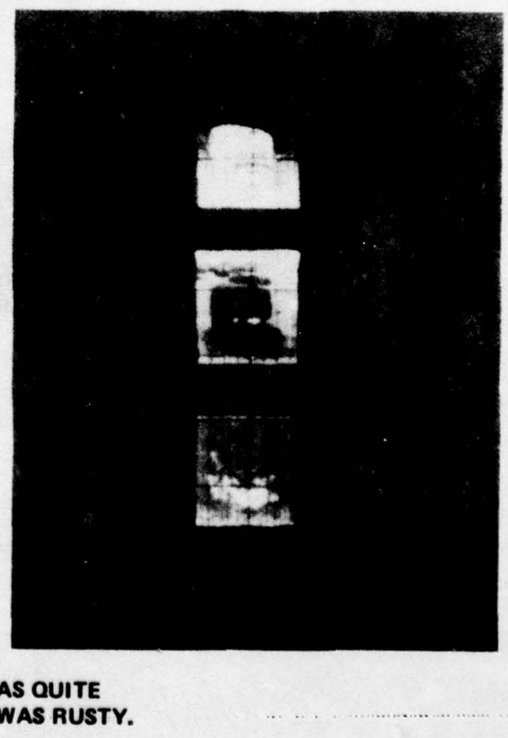


IMAGE SIZE: 75 COLUMNS, 100 ROWS

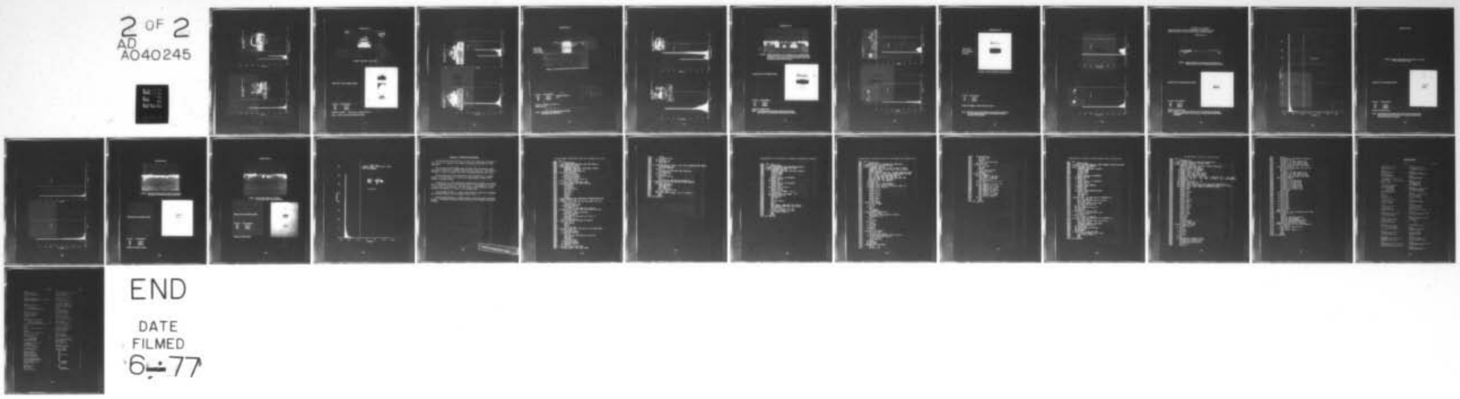
FILE NO.	WAVELENGTH
101	3.2 mm
102	10.6 μm
103	VISIBLE

RANGE TO TARGET
LEFT 46 ft 6 in. RIGHT 47 ft 8 in.

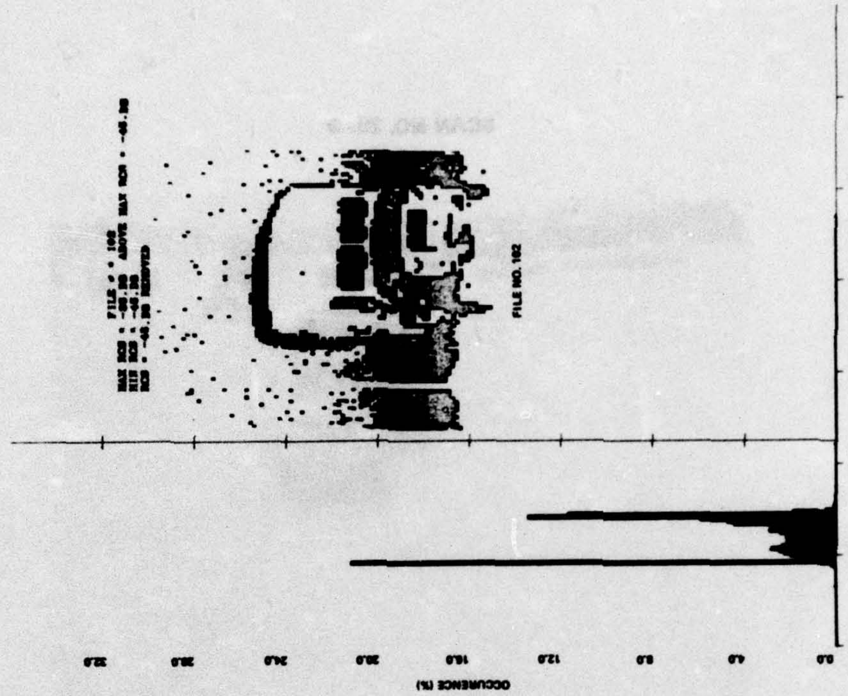
NOTE: THE PAINT ON MANY OF THE VEHICLES WAS QUITE WEATHERED. THE HOOD ON THIS TRUCK WAS RUSTY.

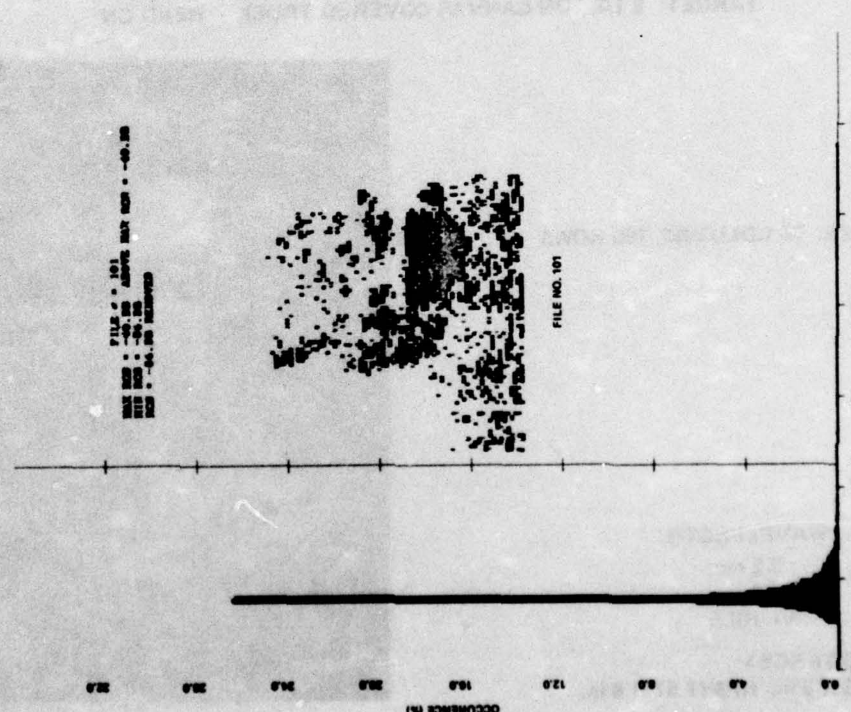
AD-A040 245 ARMY MISSILE RESEARCH AND DEVELOPMENT COMMAND REDSTO--ETC F/G 17/5
INDEX OF 3.2-MM AND 10.6-MICROMETERS IMAGE DATA TAPES.(U)
FEB 77 B D GUENTHER
UNCLASSIFIED DRDMI-TR-77-2 NL

2 OF 2
AD
A040245



END
DATE
FILMED
6-77


FILE NO. 102
OCCURENCE (%)
CROSS SECTION/m**2 (dB)


FILE NO. 101
OCCURENCE (%)
INTENSITY

SCAN NO. 29–11

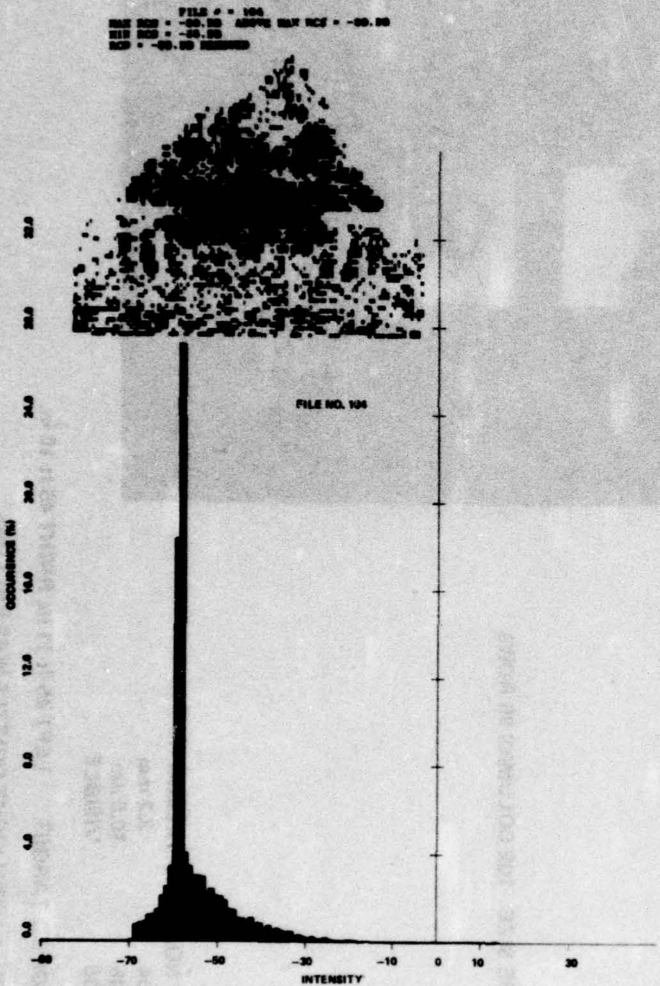
TARGET: M48 TANK – BACK VIEW

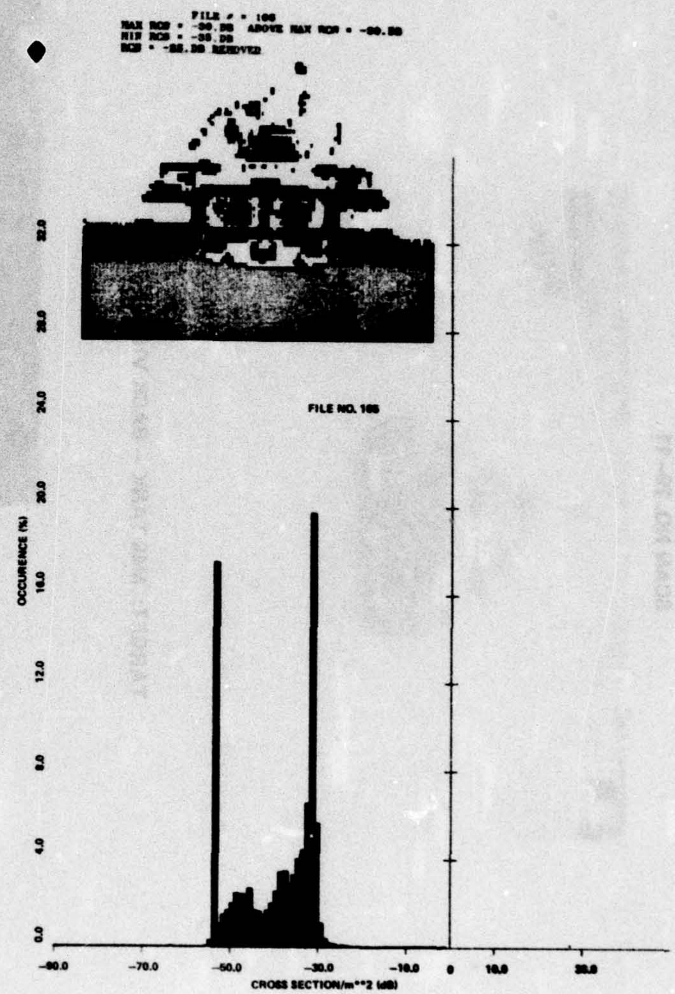
IMAGE SIZE: 102 COLUMNS 95 ROWS

FILE NO.	WAVELENGTH
104	3.2 mm
105	10.6 μm
106	VISIBLE

RANGE TO TARGET LEFT 45 ft 11 in. RIGHT 45 ft 10 in.

NOTE: A VERY LIGHT DRIZZLE WAS FALLING.


FILE NO. 104
OCCURENCE (%)
0.0
4.0
8.0
12.0
16.0
20.0
24.0
28.0
32.0
-80
-70
-50
-30
-10
0
10
30
INTENSITY


FILE NO. 106
OCCURENCE (%)
0.0
4.0
8.0
12.0
16.0
20.0
24.0
28.0
32.0
-80.0
-70.0
-50.0
-30.0
-10.0
0
10.0
20.0
CROSS SECTION/m**2 (dB)

SCAN NO. 29–12

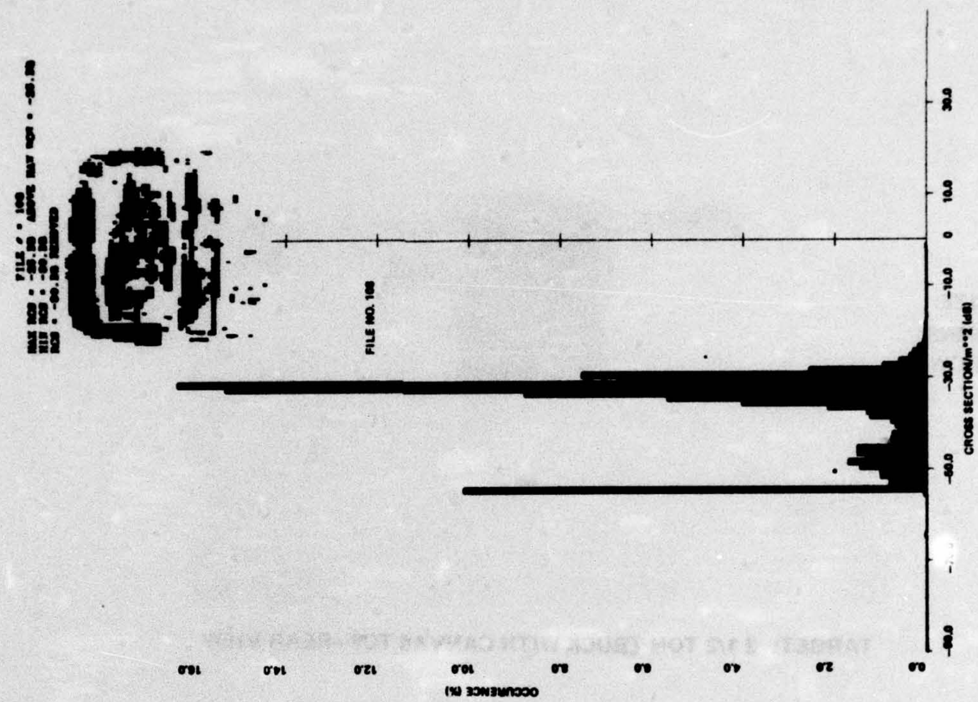
IMAGE SIZE:
78 COLUMNS
AND 95 ROWS

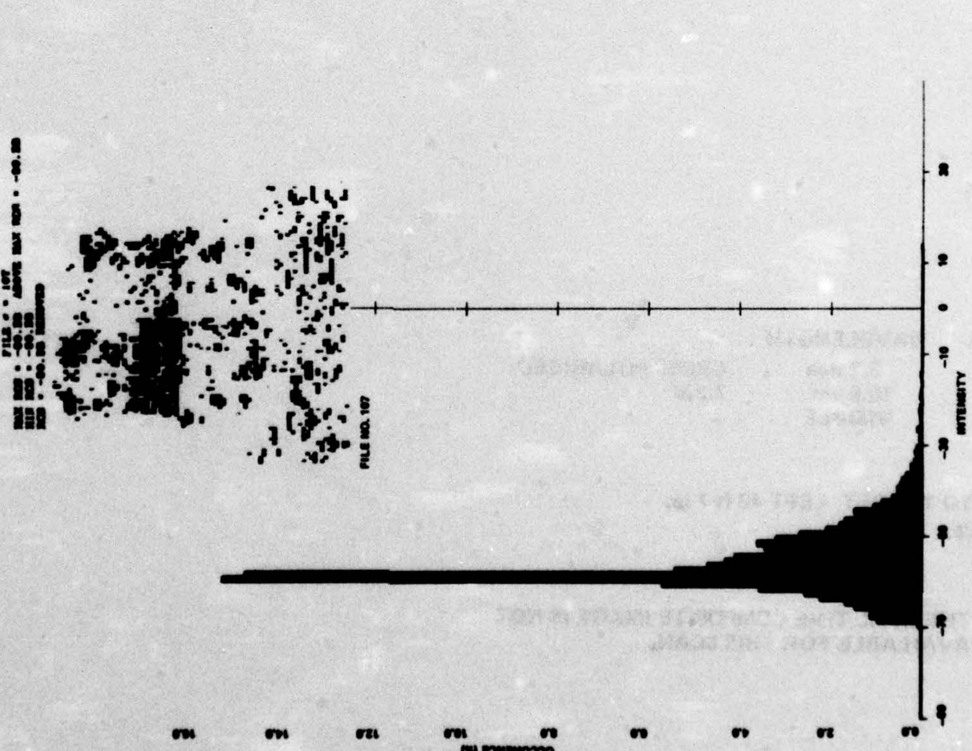
TARGET: 2 1/2 TON TRUCK WITH CANVAS TOP—REAR VIEW

FILE NO.	WAVELENGTH	V_s
107	3.2 mm	CROSS POLARIZED
108	10.6 μm	7.2 V
109	VISIBLE	–

RANGE TO TARGET LEFT 43 ft 7 in.
RIGHT 43 ft 7 in.

NOTE: THE REAL TIME COMPOSITE IMAGE IS NOT AVAILABLE FOR THIS SCAN.

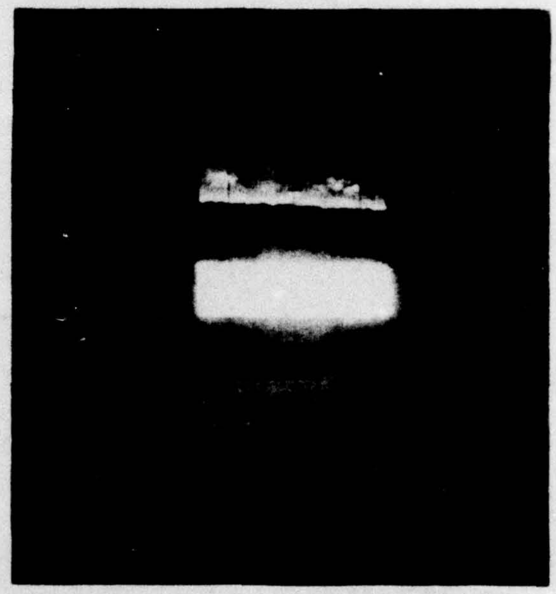

FILE NO. 106
OCCURRENCE (%)
CROSS SECTION/m**2 (dB)


FILE NO. 107
OCCURRENCE (%)
INTENSITY

SCAN NO. 29–13

TARGET: FRONT VIEW FROM LEFT TO RIGHT OF A 2 1/2 TON CANVAS COVERED TRUCK A JEEP, A CORNER CUBE MOUNTED IN THE CENTER OF A BLACK SQUARE OF PAPER MOUNTED ON WHITE CARDBOARD, AND AN M–48 TRUCK.

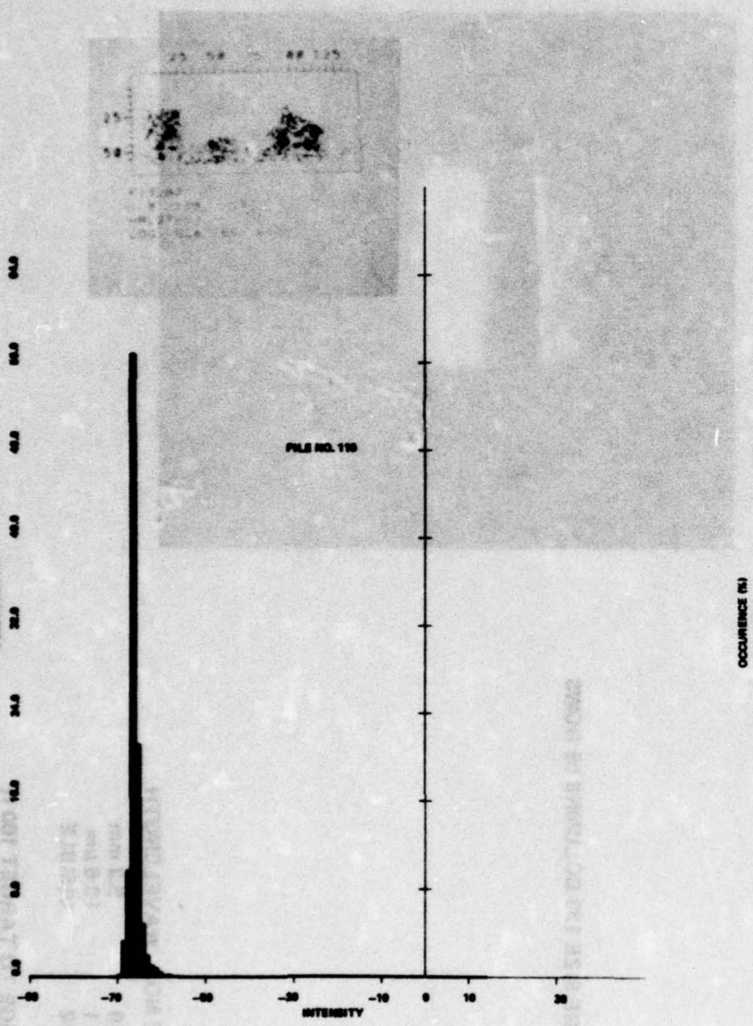
IMAGE SIZE 138 COLUMNS 59 ROWS

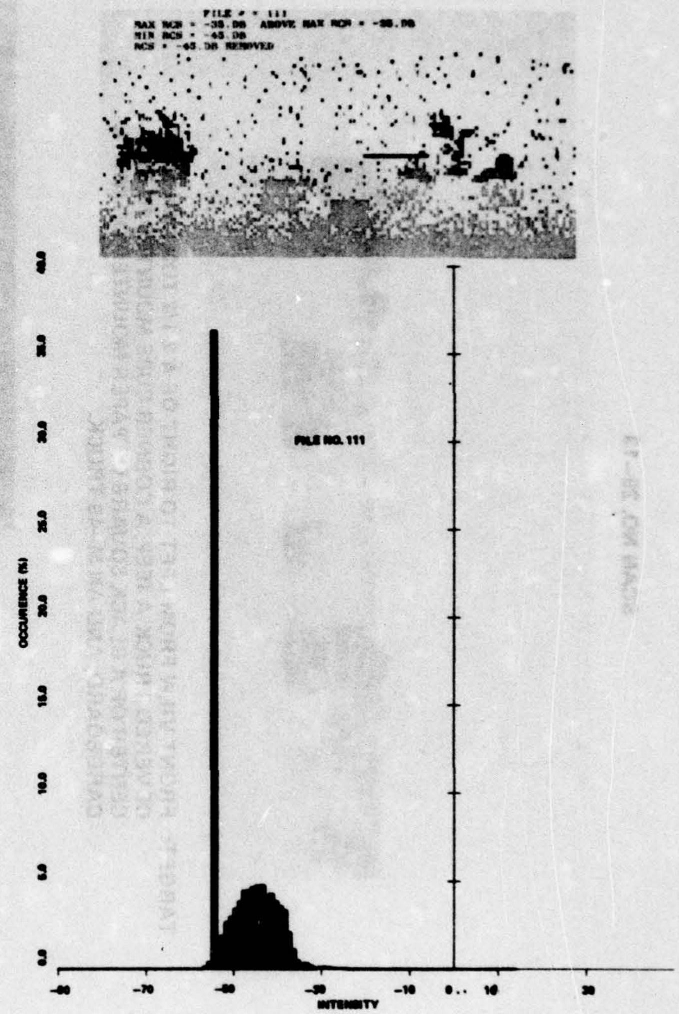


FILE NO.	WAVELENGTH
110	3.2 mm
111	10.6 μm
112	VISIBLE

RANGE TO TARGET 100 ft

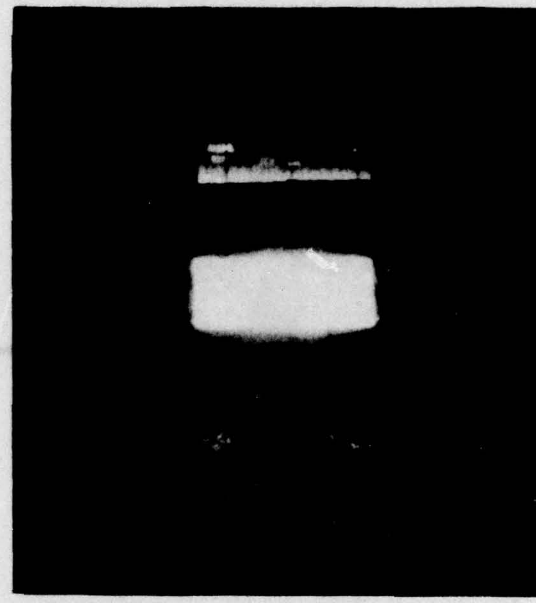
NOTE: THE TRANSMIT AND RECEIVE ANTENNA ARE CROSS POLARIZED. THE RECEIVED SIGNAL WAS QUIET WEAK.


FILE NO. 110
OCCURRENCE (%)
INTENSITY
0.0
8.0
16.0
24.0
32.0
40.0
48.0
56.0
64.0
-80
-70
-50
-30
-10
0
10
30


FILE # = 111
MAX RCS = -35.DB ABOVE MAX RCS = -35.DB
MIN RCS = -45.DB
RCS = -45.DB REMOVED
FILE NO. 111
OCCURRENCE (%)
INTENSITY
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
-80
-70
-50
-30
-10
0
10
30

SCAN NO. 29–14

IMAGE SIZE
129 COLUMNS
62 ROWS

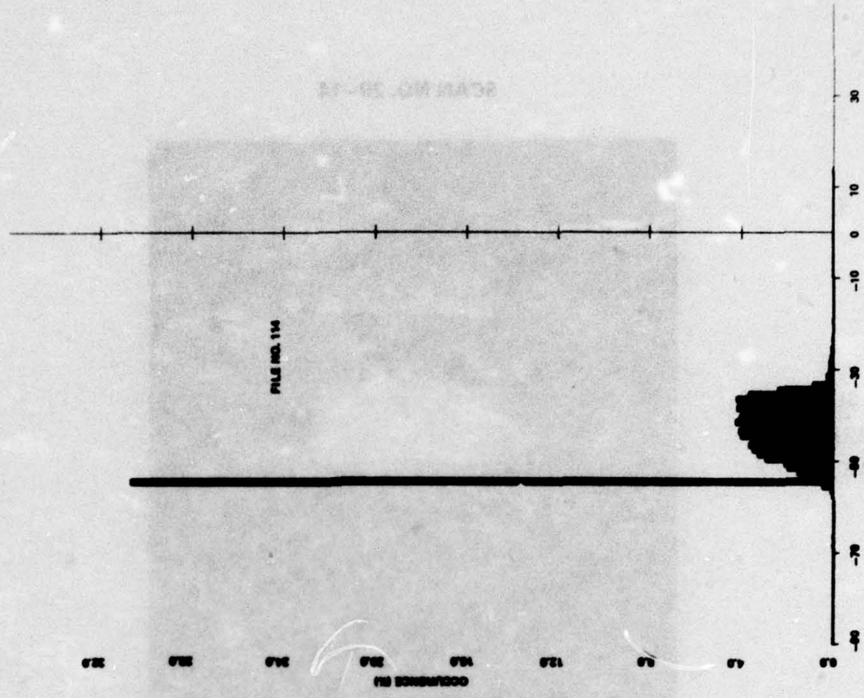


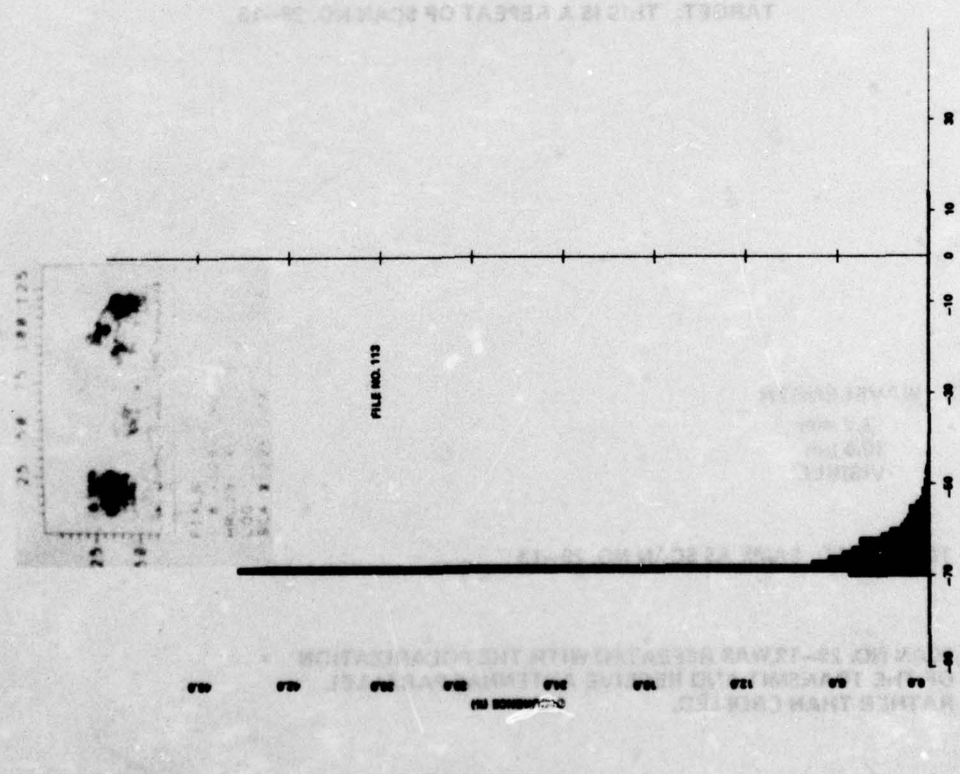
TARGET: THIS IS A REPEAT OF SCAN NO. 29–13

FILE NO.	WAVELENGTH
113	3.2 mm
114	10.6 μm
115	VISIBLE

RANGE TO TARGET: SAME AS SCAN NO. 29–13

NOTE: SCAN NO. 29–13 WAS REPEATED WITH THE POLARIZATION OF THE TRANSMIT AND RECEIVE ANTENNAS PARALLEL RATHER THAN CROSSED.


FILE NO. 114
INTENSITY
OCCURRENCE (%)


FILE NO. 113
INTENSITY
OCCURRENCE (%)

SCAN NO. 29–15, 16 AND 17

THESE FILES DO NOT CONTAIN MEANINGFUL INFORMATION. THE SCANS WERE USED TO ALIGN THE SYSTEM AT THE 400 ft RANGE.

SCAN NO. 29–18

TARGET: FRONT VIEW LEFT TO RIGHT A 2 1/2 TON TRUCK, A CORNER CUBE, A JEEP, A CORNER CUBE AND A TANK.

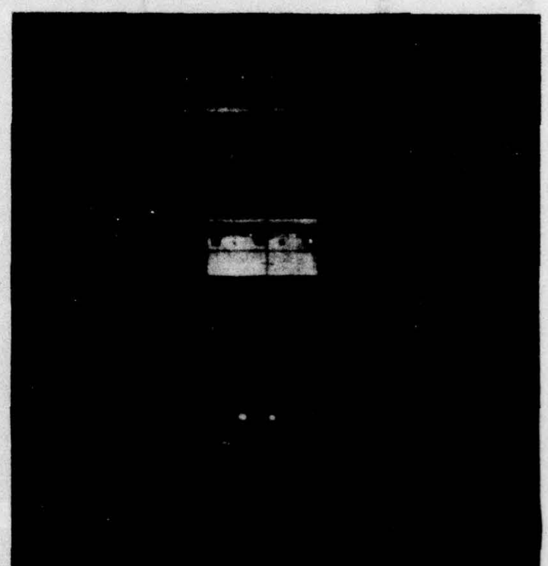
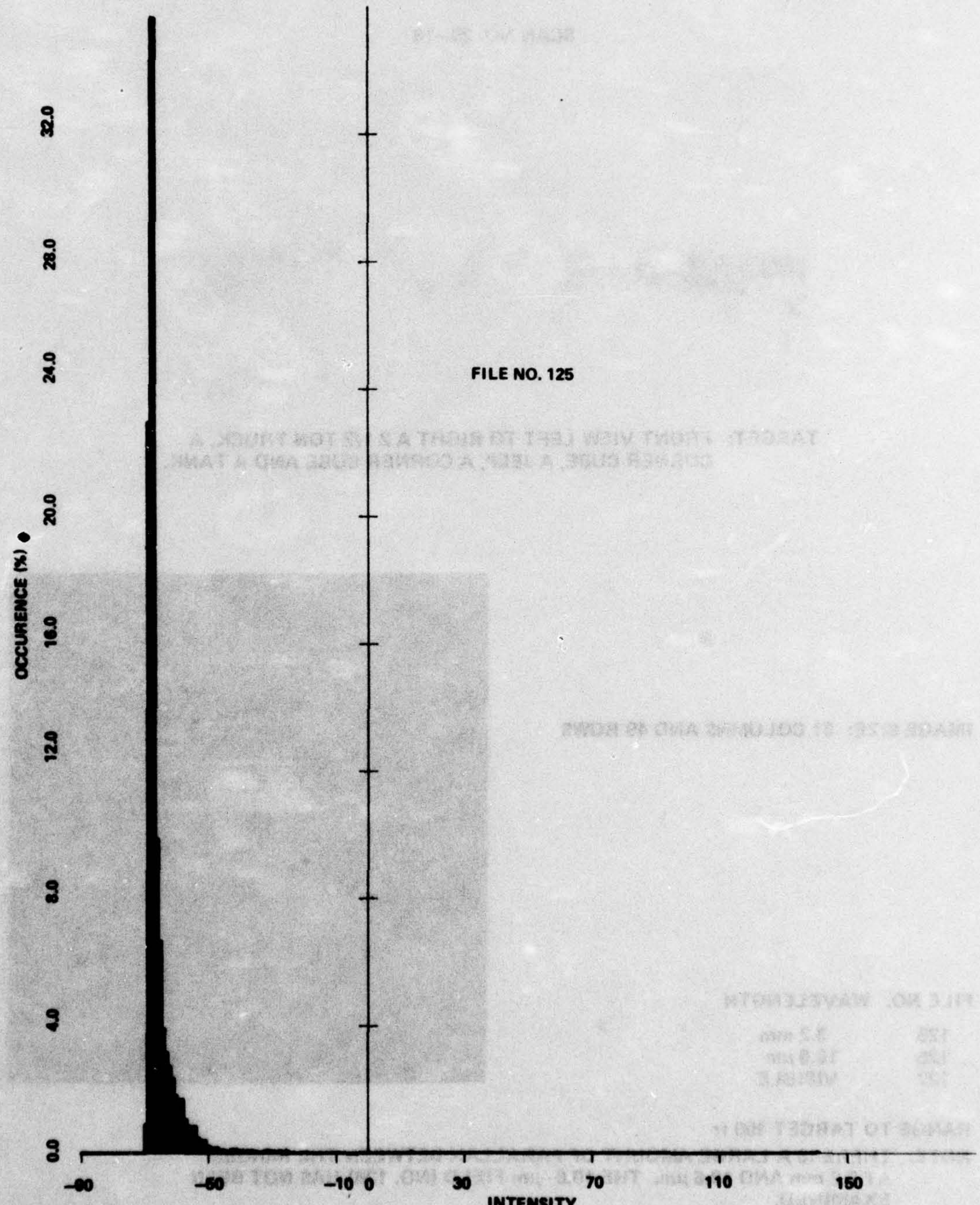


IMAGE SIZE: 81 COLUMNS AND 49 ROWS

FILE NO.	WAVELENGTH
125	3.2 mm
126	10.6 μm
127	VISIBLE

RANGE TO TARGET 400 ft

NOTE: THERE IS A LARGE AMOUNT OF PARALLAX BETWEEN THE IMAGES AT 3.2 mm AND 10.6 μm. THE 10.6–μm FIELD (NO. 126) HAS NOT BEEN EXAMINED.


FILE NO. 125
OCCURENCE (%)
0.0
4.0
8.0
12.0
16.0
20.0
24.0
28.0
32.0
-90
-50
-10 0
30
70
110
150
INTENSITY

SCAN NO. 29–19

TARGET: FRONT VIEW FROM LEFT TO RIGHT A 2 1/2 TON TRUCK, A JEEP AND A TANK

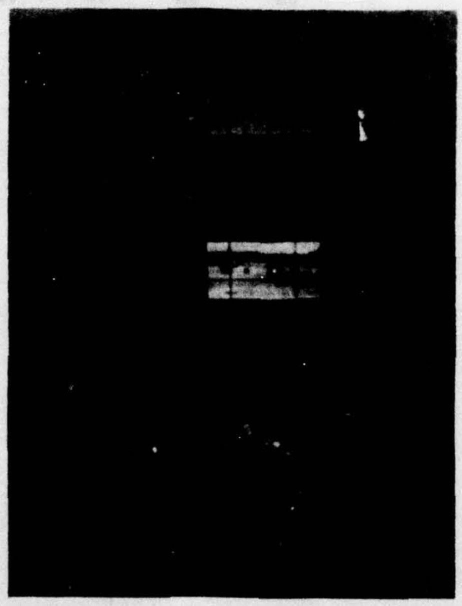
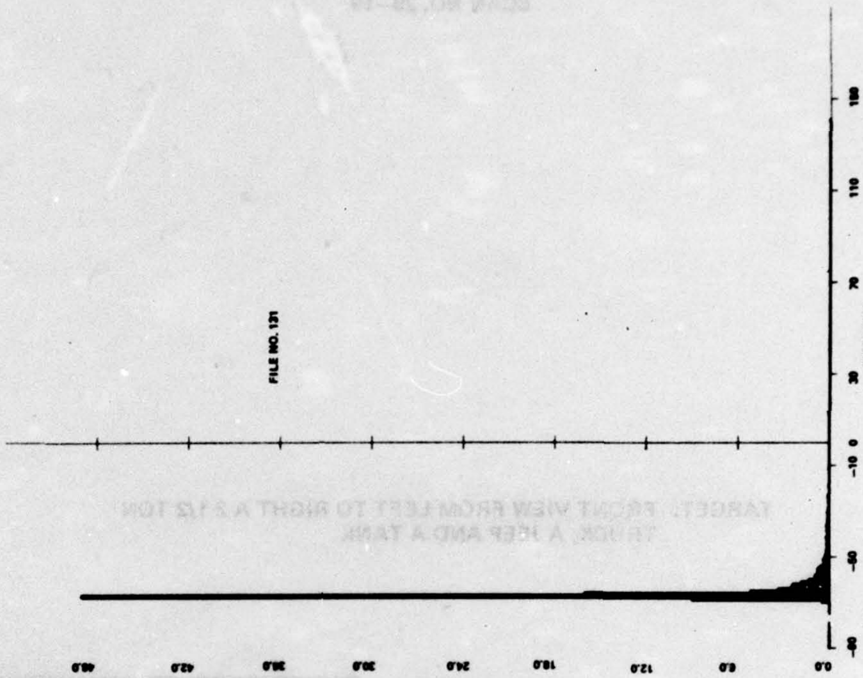


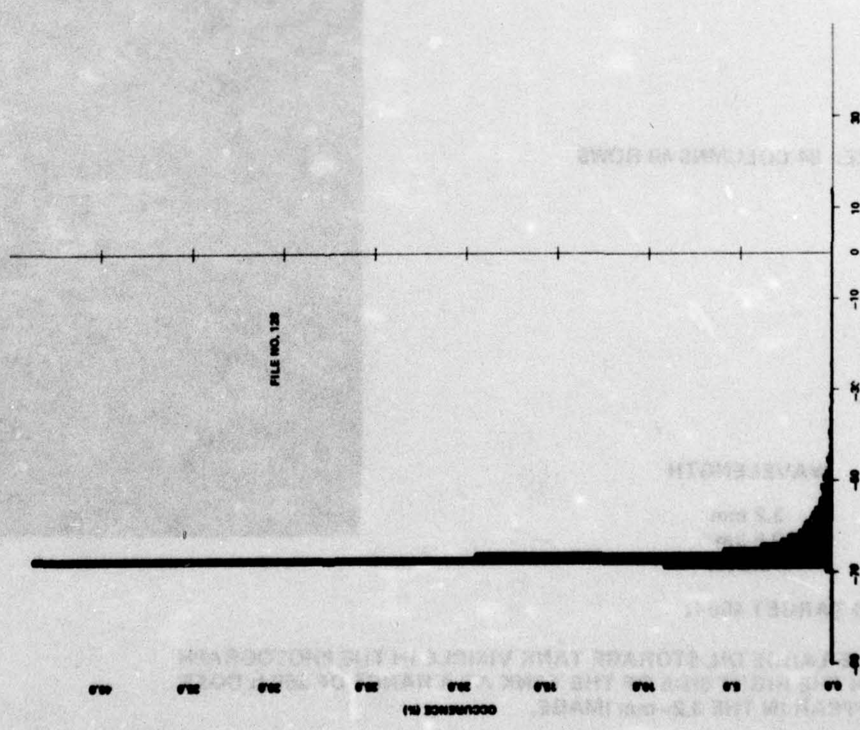
IMAGE SIZE: 84 COLUMNS 48 ROWS

FILE NO.	WAVELENGTH
128	3.2 mm
129	10.6 μm
130	VISIBLE

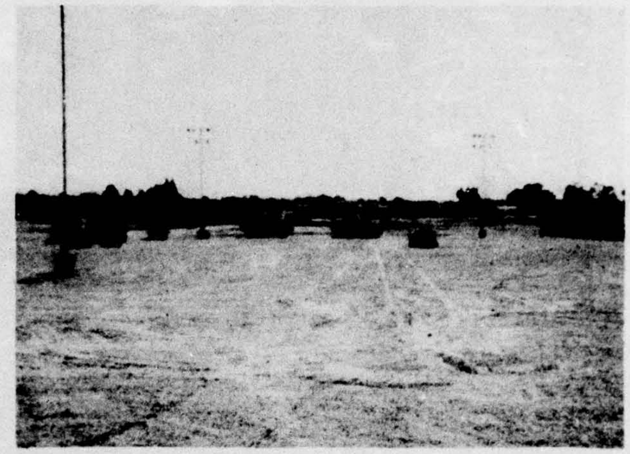
RANGE TO TARGET 400 ft

NOTE: THE LARGE OIL STORAGE TANK VISIBLE IN THE PHOTOGRAPH ON THE RIGHT SIDE OF THE TANK AT A RANGE OF 250 ft DOES APPEAR IN THE 3.2–mm IMAGE.


FILE NO. 131
INTENSITY
OCCURENCE (%)


FILE NO. 128
INTENSITY
OCCURENCE (%)

SCAN NO. 29–20



TARGET: SIDE VIEW FROM LEFT TO RIGHT OF A CANVAS COVERED 2 1/2 TON TRUCK AND AN M48 TANK

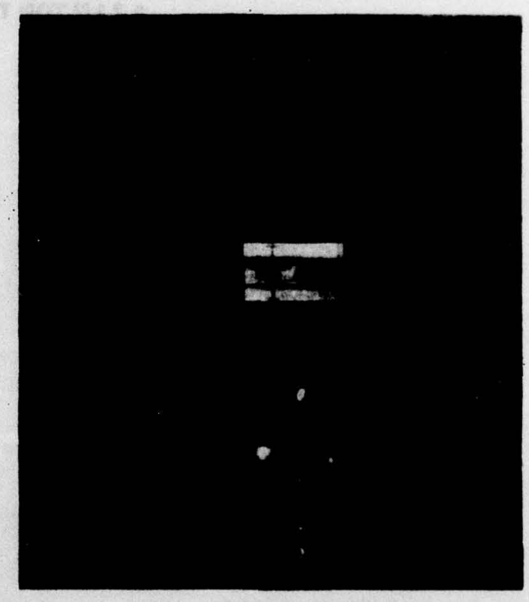


IMAGE SIZE 75 COLUMNS 40 ROWS

FILE NO.	WAVELENGTH
131	3.2 mm
132	10.6 μm
133	VISIBLE

RANGE TO TARGET IS 400 ft

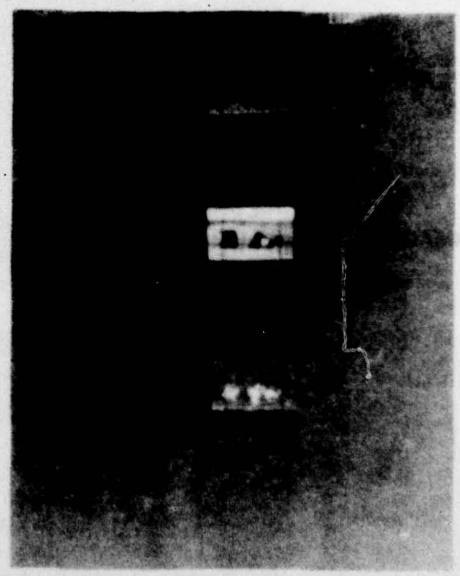
SCAN NO. 29–21

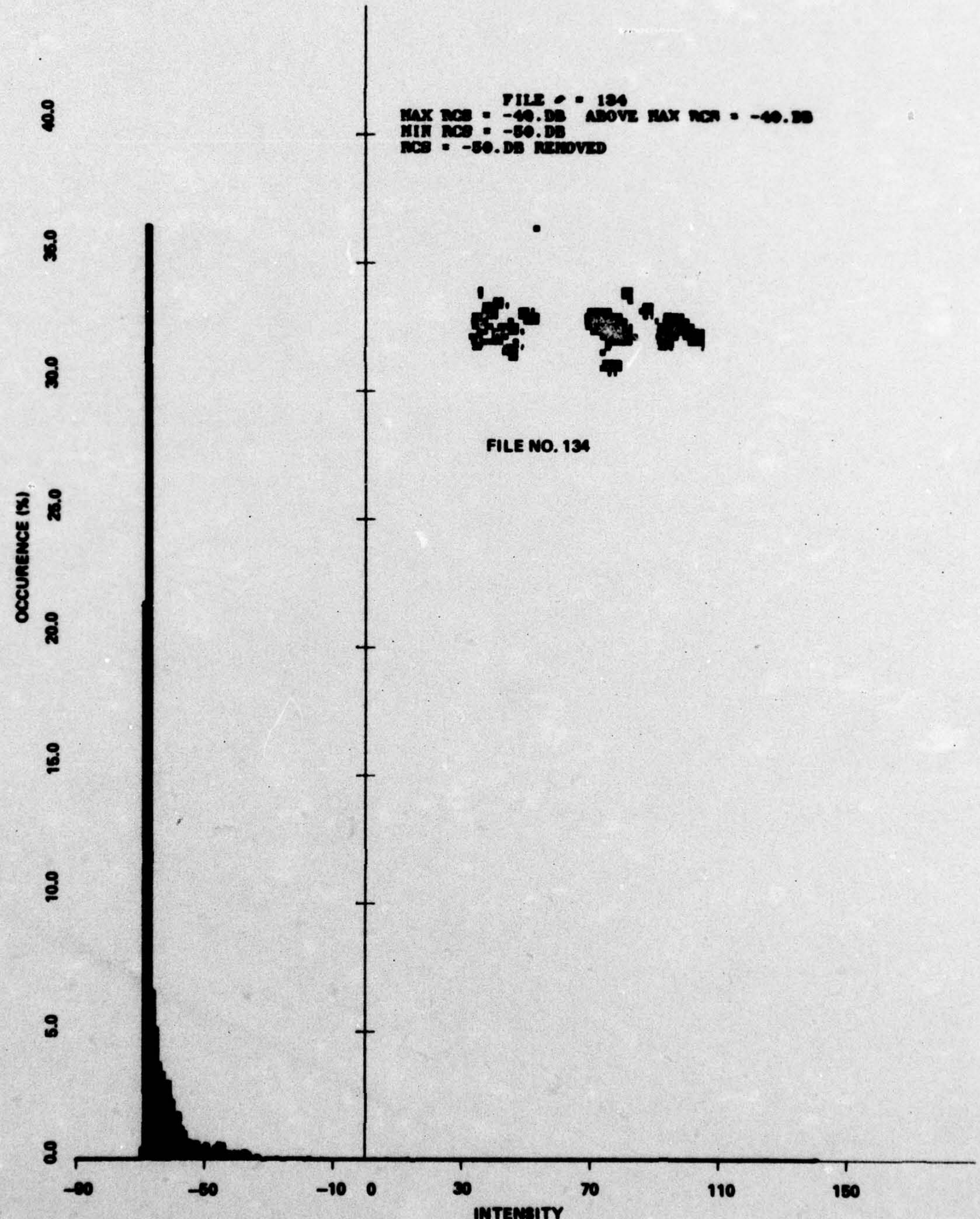
TARGET: FRONT VIEW FROM LEFT TO RIGHT
A 2 1/2 TON TRUCK AND AN M48 TANK

IMAGE SIZE 75 COLUMNS 48 ROWS

FILE NO.	WAVELENGTH
134	3.2 mm
135	10.6 μm
136	VISIBLE

RANGE TO TARGET 200 ft




FILE # = 134
MAX RCS = -40.DB ABOVE MAX RCS = -40.DB
MIN RCS = -50.DB
RCS = -50.DB REMOVED
FILE NO. 134
OCCURENCE (%)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
INTENSITY
-90
-50
-10
0
30
70
110
150

Appendix B. COMPUTER PROGRAMS

To indicate the methods used to handle the image data described in this report, a listing of the computer programs is provided in this appendix.

The program entitled RDMT reads the data from the magnetic tape and stores the data in a computer disk file for later use. The data are arranged so that individual rows can be accessed from the disk file.

Program WDT allows the binary data to be printed out in integer format. No modification to the data is made except a change from binary to integer format.

Program HIS uses the calibration information to convert the binary data to effective radar cross section values. A histogram of the data is then created and plotted. The resolution of the histogram can be modified by changing the value of the variable INT.

Program WDMT produces a crude visible image of the data by mapping the intensity values onto the numbers from 0 to 9.

Program BIWT produces a visible image of the data using a Versatic Plotter. Calibrated intensity contours can also be created using this program.

Program RDMT to Read Data Files into Computer Disk File

```
FTN L T
      PROGRAM RDMT
C READ IMAGE DATA FROM DATA TAPE AND STORE IN
C DISK FILE CALLED DATA1
C.B.D.GUENTHER 12/27/76
      DIMENSION JBUF(128) IDATA(1024) IPRAM(5)
      DIMENSION IFILE(3)
      DATA IFILE/2HDA 2HTA 1H1/
C GO TO PROPER FILE
      CALL RMPAR(IPRAM)
      IPRAM(1)=IPRAM(1)-1
   10 CALL EXEC(3 1310B)
      IPRAM(1)=IPRAM(1)-1
      IF(IPRAM(1).GT.0) GO TO 10
C READ IN FIRST RECORD
      CALL EXEC(1 110B IDATA 1024)
C CALCULATE NUMBER OF PIXALS IN FILE
      IC=IDATA(1)
      IR=IDATA(2)
      IRR=1024/IC
      LEF=1024-IC*IRR
      IC1=IC/2
      IC2=IC-IC1
      IC1=IC2
      IC=2*IC2
      IROW=0
      KTAB=0
C STORE COMPLETE ROWS CONTAINED IN RECORD ONTO DISK
  100 DO 11 KB=1 IRR
C STORE FIRST 1/2 OF ROW INTO ODD SECTOR OF DISK
      DO 12 KC=1 IC1
      L=KC+IC*(KB-1)+KTAB
   12 JBUF(KC)=IDATA(L)
      JS=2*(KB+IROW)-1
      CALL EXEC(15 102B JBUF IC1 IFILE JS)
C STORE LAST 1/2 OF ROW INTO EVEN SECTOR OF DISK
      DO 13 KC=1 IC2
      L=KC+KB*IC1+(KB-1)*IC2+KTAB
   13 JBUF(KC)=IDATA(L)
      JS=2*(KB+IROW)
      CALL EXEC(15 102B JBUF IC2 IFILE JS)
   11 CONTINUE
      IF(LEF)50 50 70
C STORE ROW DIVIDED BETWEEN TWO RECORDS
   70 IROW=IROW+1
      IFOL=LEF-IC1
      ICOL=0
      JS=0
      IF(IFOL) 19 20
C IF OVER 1/2 OF ROW STORE FIRST 1/2 IN ODD SECTOR
   20 DO 22 KA=1 IC1
      L=KA+IC*IRR+KTAB
   22 JBUF(KA)=IDATA(L)
      JS=JS+1
      CALL EXEC(15 102B JBUF IC1 IFILE JS)
      LEF=LEF-IC1
      ICOL=IC2
      IF(LEF)24 24 19
   19 DO 23 KA=1 LEF
      L=KA+IC*IRR+KTAB
   23 JBUF(KA)=IDATA(L)
      JS=JS+1
C GET NEXT RECORD FROM TAPE
   24 CALL EXEC(1 110B IDATA 1024)
```

```
      ITAB=0
      IF(IFOL)30 40 31
   30 ICOL=IC1
   31 ITAB=ICOL-LEF
      ISEC=LEF+1
      L=1
C STORE REMAINDER OF FIRST 1/2 OF ROW DIVIDED BETWEEN RECORDS
      DO 32 KA=ISEC ICOL
      JBUF(KA)=IDATA(L)
   32 L=L+1
      CALL EXEC(15 102B JBUF ICOL IFILE JS)
      IF(IFOL)40 50
   40 DO 41 KA=1 IC2
      L=KA+ITAB
   41 JBUF(KA)=IDATA(L)
      JM=1
      JS=JS+1
      CALL EXEC(15 102B JBUF IC2 IFILE JS)
C STORE LAST 1/2 OF ROW DIVIDED BETWEEN RECORDS
   50 IROW=IROW+IRR
      KTAB=ITAB+IC2*JM
      ITAB=1024-KTAB
      IRR=ITAB/IC
      LEF=ITAB-IC*IRR
      IF(IR-IROW)60 60 100
   60 WRITE(1 90)JS
   90 FORMAT("DATA LOADED" 1X I3 1X "SECTORS")
      END
      END$
**** LIST END ****
```

Program WDT to List Contents of Image File Stored in Computer

```
FTN  L T
         PROGRAM WDT
C PRINT THE CONTENTS OF THE DISK FILE DATA1
C WHICH CONTAINS AN IMAGE DATA FILE
C B.D. GUENTHER 12/27/76
         DIMENSION IBUF(128) JBUF(128) IFILE(3)
         IFILE(1)=2HDA
         IFILE(2)=2HTA
         IFILE(3)=1H1
         WRITE(1 1)
       1 FORMAT("INPUT # OF SECTORS")
         READ(1 90)ISEC
      90 FORMAT(I3)
         WRITE(1 4)
       4 FORMAT("INPUT # OF COLUMNS")
         READ(1 90)ICOL
         WRITE(1 92)
      92 FORMAT("INPUT FILE #")
         READ(1 90)IFY
         WRITE(6 91)IFY
      91 FORMAT("FILE NUMBER " I3 //)
         IC1=ICOL/2
      93 FORMAT("IMAGE ROW NUMBER " I3)
       5 FORMAT(10(I5 2X))
         IC2=ICOL-IC1
         IC1=IC2
         M=0
         DO 3 K=2 ISEC 2
         J=K-1
         M=M+1
         CALL EXEC(14 103B IBUF IC1 IFILE J)
         CALL EXEC(14 103B JBUF IC2 IFILE K)
         WRITE(6 93)M
         WRITE(6 5)(IBUF(L) L=1 IC1)
       3 WRITE(6 5)(JBUF(L) L=1 IC2)
         CALL EXEC(3 1106B -1)
         END
         END$
**** LIST END ****
```

Program HIS to Calculate and Plot a Histogram of an Image File

```
FTN L T
      PROGRAM HIS
C CALCULATE AND PLOT HISTOGRAM OF IMAGE DATA
C STORED IN DATA FILE CALLED DATA1
C B.D. GUENTHER 12/27/76
      DIMENSION JBUF(128) X(1024) Y(1024) IFILE(3)
      DIMENSION IPAT(4) IT1(4) IX(6) IY1(5) IY2(13)
      COMMON ICOM(135)
      DATA IFILE/2HDA 2HTA 1H1/ IT1/2HFI 2HLE 2H # 2H= /
      DATA SA/9999./ IPAT/10421B 21042B 42104B 104210B/
      DATA IX/2HX  2HOC 2HCU 2HRE 2HNC 2HE /
      DATA IY1/2HIN 2HTE 2HNS 2HIT 2HY /
      DATA IY2/2HCR 2HOS 2HS  2HSE 2HCT 2HIO 2HN
     12H/M 2H** 2H2  2H(  2HDB 2H )/
    1 FORMAT("INPUT # OF SECTORS")
    2 FORMAT(I3)
    3 FORMAT("INPUT # OF COLUMNS")
    4 FORMAT("INPUT SPHERE VOLTAGE")
    5 FORMAT("INPUT 001-10.6 -01-3.2 OR 000-"IS")
    6 FORMAT("INPUT FILE #")
      WRITE(1 1)
      READ(1 2)ISEC
      WRITE(1 3)
      READ(1 2)ICOL
      WRITE(1 4)
      READ(1 *)SVOL
      WRITE(1 5)
      READ(1 2)KOD
      WRITE(1 6)
      READ(1 2)IFY
C CLEAR PLOT BUFFER
      DO 10 J=1 1024
      X(J)=0.
   10 Y(J)=0.
      M2=0
      IC1=ICOL/2
      IC1=ICOL-IC1
C READ IMAGE DATA OFF DISK
      DO 20 I=1 ISEC
      CALL EXEC(14 103B JBUF IC1 IFILE I)
      IF(KOD)30 11 31
   11 A=6.91
      C=0.
      GO TO 32
   30 A=6.91
      C=26.9
      GO TO 32
   31 A=5.346
      C=26.9
   32 MIN=-90
      INT=1
C CALCULATE HISTOGRAM
      DO 19 J=1 IC1
      IF(JBUF(J))19 19 33
   33 VOL=A*((FLOAT(JBUF(J))/409.6)-SVOL)-C
      K1=IFIX((VOL-MIN)/INT)+1
      Y(K1)=Y(K1)+1
      IF(K1-M2)19 34
   34 M2=K1
   19 CONTINUE
   20 CONTINUE
C CONVERT TO % OCCURENCE
      BIC=0.
      DO 40 J=1 M2
```

```
   40 BIG=BIG+X(J)
      DO 50 J=1 M2
      K1=(2*J)-1
      K2=2*J
      Y(K1)=(X(J)*100.)/BIG
   50 Y(K2)=Y(K1)
C CREATE X-AXIS
      DO 51 J=1 M2
      K1=(2*J)-1
      K2=2*J
      X(K1)=INT*(J-1)+MIN
   51 X(K2)=INT*J+MIN
      M2=2*M2
C PLOT HISTOGRAM
   60 CALL MODE(0 2. 0. 1.)
      CALL SCAN(X Y -M2 440)
      CALL DRAW(X Y M2 444)
      IF(KOD)61 62 61
   62 CALL AXES(9.0 IY1 11.1 IX)
      GO TO 63
   61 CALL AXES(26.1 IY2 11.1 IX)
   63 CALL MODE(4 .16 .1 SA)
      CALL NOTE(2.5 6. IT1 8)
      CALL NOTE(SA SA IFX 0)
      CALL MODE(10 SA IPAT 4.)
      CALL TONE(0. 0. 440 0)
      CALL TONE(X Y M2 1)
      CALL DRAW(0. 0. 1 9000)
      CALL DRAW(0 0 0 9999)
      CALL EXEC(3 1106B -1)
   80 STOP
      END
      END$
**** LIST END ****
```

Program WDT to Create a Visible Image Uisng a Line Printer

```
FTN  L T
      PROGRAM WDMT
C CREATE A VISIBLE RECORD OF IMAGE STORED IN DISK FILE DATA1
C BY USING THE LINE PRINTER
C B.D. GUENTHER 12/27/76
      DIMENSION JBUF(128) IFILE(3)
      IFILE(1)=2HDA
      IFILE(2)=2HTA
      IFILE(3)=1H1
      WRITE(1 1)
    1 FORMAT("INPUT # OF SECTORS")
      READ(1 90)ISEC
   90 FORMAT(I3)
      WRITE(1 4)
    4 FORMAT("INPUT # OF COLUMNS")
      READ(1 90)ICOL
      WRITE(1 91)
   91 FORMAT("INPUT OFFSET")
      READ(1 6)IOF
    6 FORMAT(I4)
      WRITE(1 92)
   92 FORMAT("INPUT NORMALIZATION")
      READ(1 6)INOR
      IC1=ICOL/2
      IC2=ICOL-IC1
      IC1=IC2
C CONVERT LEFT 1/2 IMAGE DATA TO INTEGERS 0-9
      DO 2 J=1 ISEC 2
      CALL EXEC(14 103B JBUF IC1 IFILE J)
      DO 10 JK=1 IC1
      JBUF(JK)=(JBUF(JK)-IOF)/INOR
      IF (JBUF(JK))20 20 21
   20 JBUF(JK)=0
   21 IF(10-JBUF(JK))30 30 10
   30 JBUF(JK)=9
   10 CONTINUE
C WRITE LEFT 1/2 OF ALL ROWS
    2 WRITE(6 5)(JBUF(JC) JC=1 IC1)
    5 FORMAT(69(I1))
C SKIP A PAGE
      CALL EXEC(3 1106B 63)
C CONVERT RIGHT 1/2 IMAGE DATA TO INTEGERS 0-9
      DO 3 K=2 ISEC 2
      CALL EXEC(14 103B JBUF IC2 IFILE K)
      DO 40 KL=1 IC2
      JBUF(KL)=(JBUF(KL)-IOF)/INOR
      IF(JBUF(KL))50 50 51
   50 JBUF(KL)=0
   51 IF(10-JBUF(KL))60 60 40
   60 JBUF(KL)=9
   40 CONTINUE
C WRITE RIGHT 1/2 OF ALL ROWS
    3 WRITE(6 5)(JBUF(JC) JC=1 IC2)
      CALL EXEC(3 1106B -1)
      END
      END$
**** LIST END ****
```

Program BIWT to Create a Visible Image

```
FTN L T
      PROGRAM BIWT
C POINT PROCESS IMAGE IN DISK FILE CALLED DATA1
C AND WRITE ON VERSATEC IN BINARY FORMAT
C B.D.GUENTHER 12/27/76
      DIMENSION JBUF(128) IBUF(256) IFILE(3) KBUF(132)
      DATA IFILE/2HDA 2HTA 1H1/
    1 FORMAT("INPUT # OF SECTORS")
    2 FORMAT("INPUT # OF COLUMNS")
    3 FORMAT("INPUT # OF ROWS")
    4 FORMAT("INPUT MAX PIXEL VALUE")
    5 FORMAT("INPUT MIN PIXEL VALUE")
    6 FORMAT("INPUT SPHERE VOLTAGE")
    8 FORMAT(5X "MAX RCS = " F4.1 "DB" "  ABOVE MAX RCS = " F4.1 "DB")
    9 FORMAT(5X "MIN RCS = " F4.1 "DB" / 5X "RCS = " F4.1 "DB REMOVED")
    7 FORMAT(I3)
   99 FORMAT(15X "FILE # = " I3)
   98 FORMAT("INPUT FILE #")
   97 FORMAT("INPUT 001 FOR 10.6 -01 FOR 3.2 OR 000 FOR VIS")
   96 FORMAT("INPUT PIXEL VALUE TO BE REMOVED OR MIN PIXEL VALUE")
   95 FORMAT("INPUT PIXEL INTENSITY ABOVE MAX PIXEL")
      WRITE(1 98)
      READ(1 7)IFY
      WRITE(1 1)
      READ(1 7)ISEC
      WRITE(1 2)
      READ(1 7)IC
      WRITE(1 3)
      READ(1 7)IR
      WRITE(1 4)
      READ(1 *)VMAX
      WRITE(1 95)
      READ(1 *)VX1
      WRITE(1 5)
      READ(1 *)VMIN
      WRITE(1 96)
      READ(1 *)VX2
      WRITE(1 6)
      READ(1 *)VS
      WRITE(1 97)
      READ(1 7)KOD
      IC1=IC/2
      IC2=IC-IC1
      IC1=IC2
      IC=2*IC2
      WRITE(6 99)IFY
      WRITE(6 8)VMAX VX1
      WRITE(6 9)VMIN VX2
C POINT PROCESS OF IMAGE
      IF(KOD)21 32 31
   21 A=6.91
      C=26.9
      GO TO 33
   31 A=5.346
      C=26.9
      GO TO 33
   32 A=6.91
      C=0
   33 VMAX=409.6*(((VMAX+C)/A)+VS)
      VMIN=409.6*(((VMIN+C)/A)+VS)
      VX1=409.6*(((VX1+C)/A)+VS)
      VX2=409.6*(((VX2+C)/A)+VS)
      DO 10 I=1 IR
      IO=2*I-1
```

```
      IE=2*I
      CALL EXEC(14 103B JBUF IC1 IFILE IO)
      DO 100 J=1 IC1
      IF(JBUF(J).GT.VMAX) JBUF(J)=VX1
      IF(JBUF(J).EQ.VX2) JBUF(J)=VMIN
      IF(JBUF(J).LT.VMIN) JBUF(J)=VMIN
      VO=256.*(JBUF(J)-VMIN)/(VMAX-VMIN)
  100 IBUF(J)=IFIX(VO)
      CALL EXEC(14 103B JBUF IC2 IFILE IE)
      DO 200 J=1 IC2
      JD=J+IC1
      IF(JBUF(J).GT.VMAX) JBUF(J)=VX1
      IF(JBUF(J).EQ.VX2) JBUF(J)=VMIN
      IF(JBUF(J).LT.VMIN) JBUF(J)=VMIN
      VO=256.*(JBUF(J)-VMIN)/(VMAX-VMIN)
  200 IBUF(JD)=ABS(VO)
      DO 400 J=1 IC
      IF(IBUF(J).LT.3)GO TO 20
      IF(IBUF(J).LT.5)GO TO 30
      IF(IBUF(J).LT.9)GO TO 40
      IF(IBUF(J).LT.17)GO TO 50
      IF(IBUF(J).LT.33)GO TO 60
      IF(IBUF(J).LT.65)GO TO 70
      IF(IBUF(J).LT.129)GO TO 80
      IBUF(J)=255
      GO TO 400
   20 IBUF(J)=0
      GO TO 400
   30 IBUF(J)=3
      GO TO 400
   40 IBUF(J)=7
      GO TO 400
   50 IBUF(J)=15
      GO TO 400
   60 IBUF(J)=31
      GO TO 400
   70 IBUF(J)=63
      GO TO 400
   80 IBUF(J)=127
  400 CONTINUE
C PACK TWO 8 BIT PIXALS INTO ONE 16 BIT WORD
      DO 300 J=1 IC1
      JO=2*J-1
      JE=2*J
      IBUF(JO)=IAND(377B IBUF(JO))
      IBUF(JO)=IBUF(JO)*256
      IBUF(JO)=IAND(177400B IBUF(JO))
      IBUF(JE)=IAND(377B IBUF(JE))
  300 KBUF(J)=IOR(IBUF(JO) IBUF(JE))
C PLOT 8 IDENTICAL ROWS FOR EACH IMAGE ROW
      DO 10 K=1 8
      CALL EXEC(2 106B KBUF IC1)
   10 CONTINUE
      CALL EXEC(3 1106B -1)
      STOP
      END
      END$
**** LIST END ****
```

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